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Regeneration in Plants*

BY KARL GOEBEL

The phenomena of regeneration in plants have been known much longer than those in animals. For cuttings of twigs and the separated leaves of many plants to become independent individuals, or to give rise to them, is an every-day occurrence. The anatomical changes which take place are, in general, well known. On the other hand, relatively few investigations have been made as to the factors which set up regeneration and determine the kind of organs and the manner of their formation in regeneration. It is evident without further discussion that a knowledge of these facts would be of the greatest importance for every theory of organic development and heredity, and in brief for all investigations which might be classed under "causal morphology." It is necessary to group the facts from some general point of view before a theory can be formulated. I have already attempted this some time since, and will give in the following a brief restatement of the conclusions already reached together with the results of some new experiments. It will be profitable to repeat some of my previously formulated propositions † in a somewhat modified form.

1. The phenomena of regeneration imply a development of dormant or latent rudiments. These rudiments (*Anlagen*) are present as vegetative points (embryonic tissue) and are set into

* Read by invitation before the Botanical Society of America, at Washington, December 31, 1902.

† Goebel, K. Ueber Regeneration im Pflanzenreich. Biol. Centralb. 22: 385–397, 417–438, 481–505. 1902. See also discussion and literature in Goebel, Organographie der Pflanzen, 35–43. 1898.

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activity by injuries, or they are outwardly invisible, there being simply a disposition or tendency toward the formation of new structures, as in adventitious buds, or adventitious roots. The two cases are not sharply distinguishable from each other, since in both the unfolding of a rudiment, or the awakening of a predisposition, is conditioned by the reciprocal connections of organs with one another, which are designated as "correlations."

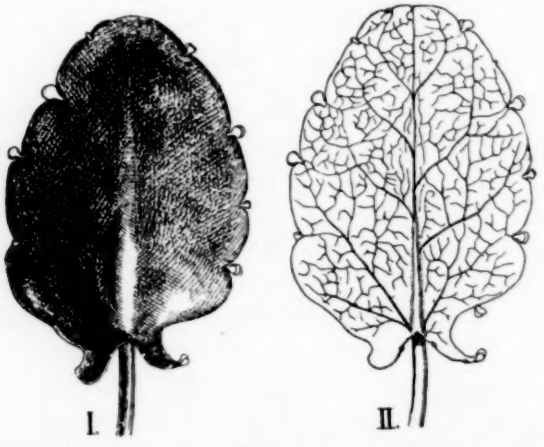

FIG 1. *Bryophyllum crenatum.* Detached leaf, which has developed sprouts upon its edge, each with two small leaves. (In II made translucent so that the venation is visible.)

Some examples will make this point clearer. It is well known that every tree has hundreds of dormant buds which ordinarily do not awake, but which may be set into activity by cutting back, or by the destruction of the leaves during the vegetative season. My investigations were most closely concerned with the development of the buds which are normally present on the leaves of some Crassulaceae, as for example *Bryophyllum crenatum*, and which are laid down even in the embryonic condition of the leaves. Their presence implies that the leaves here serve the function of reproduction, since every leaf that is cut off, if laid in damp earth, produces numerous young plants in the notches of its edges.

The next question to be considered is by what means the development of the shoot-rudiments existing on the leaves is set in ac-

tion. Investigation showed that this development may be induced by cutting the larger vascular bundles, and also the veins of the leaf. The leaf remains fresh and attached to the plant, but becomes covered with young sprouts through the growth of the rudiments on the edge of the leaf. We see by this that a disconnection, or interruption of the conducting system gives the stimulus for the further development of the resting vegetative point on the leaf; but why this interruption should act as a stimulus has not yet been explained. Further investigations may throw some light upon this point. The vegetative points were removed from a number of plants except those found on the margins of the leaves. The result of this operation was that the vegetative points which usually remain dormant became active. The conductive system was not broken but the goal of the system was removed in a manner. For the vegetative points are to be considered as centers of attraction for the constructive material which is carried thither to be used in the building up of new organs. We can say, therefore, that the presence of the vegetative points on the shoot prevents the development of those on the leaves. The former lay claim to the conducting channels that run through the leaf, and only when these are broken or the vegetative point of the shoot is removed do those on the leaves develop. A correlation is clearly apparent.

Whether we have to do in this case with a quantitative relation to constructive material, as was assumed above for the sake of simplicity, or with imperfectly understood specific reactions to stimuli along the conducting system must for the present remain unsettled.

It appeared of interest to me to determine the behavior of plants that have no vegetative points on the leaves, but possess only the tendency to construct adventitious shoots from cells which have passed over into permanent condition. The best known example of this is *Begonia Rex*. Florists propagate this plant by setting leaves cut from the stems in damp sand. At the base of the blade adventitious shoots appear; and one can easily induce them to appear on other places by cutting the larger veins of the leaf.

If the above proposition is correct, it would necessarily follow

that we could induce the development of these adventitious shoots on leaves as well, which still retain their connection with the plant. If the attempt were to prove successful, we should have induced experimentally in *Begonia Rex* a phenomenon which is normally characteristic of two other species of this genus. Systematists state that in *B. sinuata* and *B. prolifera* both leafy and flowering shoots develop on the leaf-blade and even from its base.

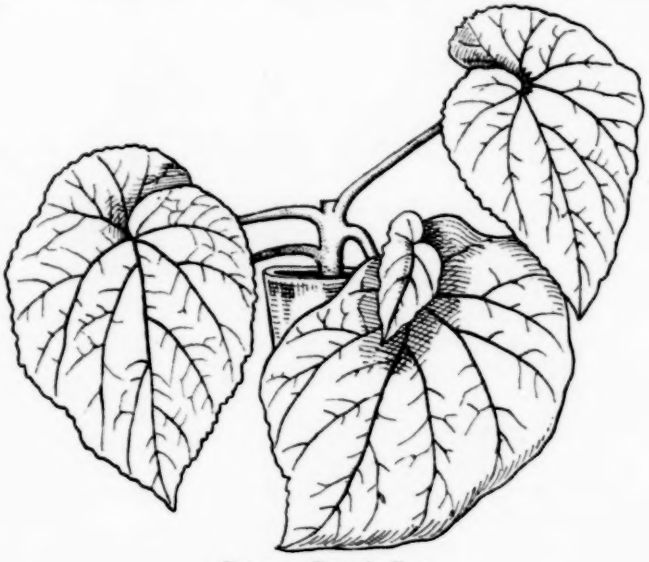

FIG. 2. *Begonia Rex.*

It was found possible to induce the production of shoots on the leaves, as shown in *f. 2*, although not, it is true, as quickly as in *Bryophyllum*. The method used was the same as in the previous instance. All vegetative points that could be found were removed. The plants soon began to develop dormant buds that had been hidden, and produced adventitious shoots in the axes: all these shoots were removed and the process was repeated. After about three months, there appeared on the leaves of the plants treated in this manner adventitious shoots which developed into plants. The shoots came from the bases of the leaf-blades, where the large veins join. Here then we have the same phenomenon as in *Bryophyllum:* that is the removal of the vegetative points of the shoots starts the development. In this case, how-

ever, we have to do, not with previously laid-down primordia, but with a disposition on the part of the tissues of the leaf; and we have actually brought about a form-relation present in other species but normally absent from *Begonia Rex*.

2. When a part of a plant is removed direct restoration occurs only when we have to do with embryonic tissue, such as that of the vegetative point. When parts of plants which have assumed their permanent character are concerned the rupture and wounding have the effect of inducing a portion of the cells to return to the embryonic condition and to produce structures which give rise to one or more new plants. Many seedlings have a remarkable power of regeneration.

There is no important and invariable difference in the phenomena of regeneration in plants and in animals, but the course of procedure that has been described is highly characteristic of plants. While in animals the parts that have been lost must be replaced directly, this is the exception in plants. A few illustrations will make this clearer.

(*a*) Embryonic tissue. It has long been known that vegetative points of roots and shoots, if wounded, easily regenerate what has been lost. Fern-fronds have, as is known, the peculiarity that the tip remains in an embryonic condition for a long time, while it soon passes into permanent form in most spermatophytes. I split young leaves on *Polypodium Heracleum* lengthwise into two similar or dissimilar halves. When the parts were alike the tips of each regenerated a perfect leaf; when the parts were unequal, the regeneration on the smaller was much less marked. Similar phenomena are to be observed in the tips of roots or shoots.

(*b*) On the other hand when the parts of a leaf which have assumed permanent form are removed, the restoration does not take place; a separated leaf of *Begonia* for example does not regenerate a new shoot-axis with roots which continue life as a part of the regenerated plant, but there develop on the leaf new plants which soon become entirely independent of the original leaf. The cells of the leaves of many plants are easily induced to develop new plants; they contain all the necessary germ-plasm, but are not in a position to coöperate with one another in such manner as to directly replace what was lost by newly constructed tissues.

The one exception to the above established by Hildebrandt, Winkler and others is the case of first leaves of the seedlings of *Cyclamen Persicum*. When one removes the leaf-blades in this plant there develop to the right and left of the petiole new blades. But in this case also, as I think I proved, there is only a development of latent rudiments. From the point of view of embryology, the leaf-stalk is a part of the leaf-primordium, in which the development of the leaf-blade is arrested. This condition of arrest is by no means so well established in the seedling as it is in later stages, and consequently it can be overcome. When the blades are removed from leaves in older plants these organs die without forming new blades.

Similar conclusions were arrived at in all cases in which a critical examination was made. The phenomena of regeneration in leaves, as described in the literature of the subject, will not bear careful examination. On the other hand, it can be shown that seedlings often possess a greater capacity for the formation of new organs than older plants. Not a few seedlings develop adventitious shoots on the hypocotyl even without being wounded. Such shoots have also been seen on the leaves of young plantlets of *Lycopodium inundatum*, but not on those of older plants.

3. The character of the organ constructed depends upon the condition of the plant at the time regeneration ensued. Illustrations of this fact are quite as apparent in the lower as in the higher plants. The fungi may be cited first. From investigations by Van Tieghem and Brefeld we know that when, for example, the pileus of certain agarics is cut off, there is a regeneration from the stalk, not of a new pileus, but of one or more complete fruiting bodies. We see here that a direct restoration of the part that has been lost does not take place, but the new organ is dependent upon the condition of the plant, in that as a result of the wound, the mycelium proceeds immediately to build up a new fruiting body, and does not go through a longer vegetative period.

It is to be remembered that the dependence of the formation of organs upon external conditions is much greater in fungi than in the higher plants. If the sporangium is removed from the fruiting hypha of *Phycomyces* there is developed a new fruiting hypha from the stalk of the old one. But when regeneration takes

place on an entirely immersed fruiting hypha the external factors influential in the production of fruiting hyphae are lacking and a vegetative hyphal branch developes. It appears therefore that the above-mentioned relation generally holds good.

Formerly I believed that in certain cases in fungi a direct restoration of wounded fruiting bodies could take plaee. I cut

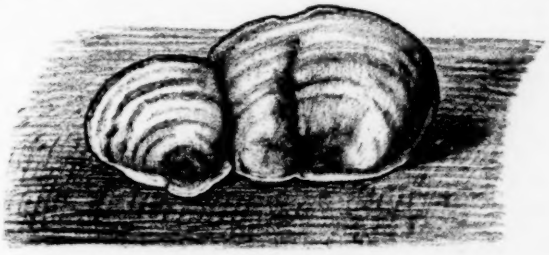

FIG. 3. *Stereum hirsutum.* Fruit-bodies from beneath.

pieces from the fruit of *Stereum hirsutum*, and found after some months, growth being slow in this instance, that the bodies had reassumed somewhat the shape of the fruit before wounding. Closer investigation showed that this was not the case however. The fruit-body exhibits a characteristic zonal formation (*f. 3*). The new formation does not in any way add to the zone formation of the old fruit-bodies but is entirely independent of it (*f. 4*).

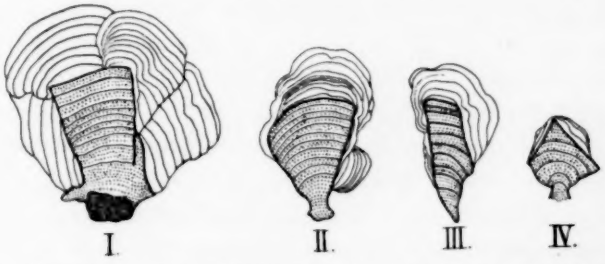

FIG. 4. *Stereum hirsutum.* Regeneration of the fruit-bodies. The old portions are dotted.

They are actually new fruit-bodies, but since they are scarcely individualized they soon grow together with the old fruit and so appear as regenerated parts of the latter. Injured fruit-bodies growing in close proximity often become concrescent and so show that the above conclusion is correct.

Among higher plants *Begonia* is a good example. When parts of leaves are taken from plants of *Begonia Rex* in a flowering condition, these proceed to the formation of flowers much more quickly than those parts taken from plants not in flower (Sachs), and in *Begonia discolor*, which forms bulbils in the autumn, we get leafy shoots as regenerated organs in the spring, but bulbils in the autumn (Wakker).

I have cited other examples of this relationship, which forms an important part of the theory of metamorphosis, in another place.

4. The character of the organs formed in regeneration is dependent to a very slight degree only on outside factors. It is conditioned by the structure of the parts of the plants concerned, particularly by the direction in which the constructive material moves; the wound-stimulus must also be taken into consideration.

Vöchting's well-known investigations have directed the attention of botanists to the polarity apparent in regeneration. New shoots are produced at the tips of old shoots, and roots from the bases. This process is reversed in root-cuttings. Leaves show no polarity in regeneration; the new organs appear at the base. The cause of these differences is the next point to determine. Vöchting held that above all *difference in growth* was the determining factor. Organs which have limited growth show regeneration at the base; those which have unlimited growth show polarity.

I can not agree with this conclusion. The relations described above are the ones which, in my belief, are to be considered most important. In a foliage leaf the constructive materials are in the process of movement toward the stem. When we cut off the leaf, the new organs are in accord with the above idea produced at the base. In shoots and roots we have a double movement: on the one hand toward the vegetative point of the shoot, and on the other toward the vegetative point of the root. This implies the existence of polarity in these instances.

Space does not admit the citation of all of the facts bearing upon this point, but a few examples may be mentioned. If Vöchting's theory were correct, *all* organs of limited growth would necessarily show similar relations. But this is not the case. The

leaves of the foliaceous liverworts do not show any tendency to limit regeneration to the bases. This however is easily explainable from my point of view. These leaves are composed of only one or two layers of cells and so have at the time of separation neither a very large amount of constructive materials, nor definite conducting systems to carry them. They form adventitious shoots only when, after being cut off, they have been able to perform the photosynthetic processes for some time. No cause exists for the limitation of regeneration to the base of the leaf. The pieces from the flanks of the thallus of *Fegatella* behave similarly.

On the other hand the leaves of *Bryophyllum* produce, in general, no new structures of their own when cut off, all of the constructive material being used by the vegetative points already in existence in the indentations. The removal of these on a number of leaves caused the formation of roots at the base of the leaves, and in one instance of a bud also. These facts seem to lead to the conclusion that:

1. The vegetative points serve as centers of attraction for the constructive material necessary for the formation of new organs.

2. As long as the leaf remains attached to the stem the materials flow into the stem; when the leaf is detached, the materials are appropriated by the vegetative points of the leaf.

3. The removal of the vegetative points of the leaf is followed by the transfer of the place of origin of new structures to a point down the conducting tracts at the base of the leaf.

The above are the chief conclusions so far attained, but much more research will be necessary before the processes of regeneration are well understood.

MÜNICH, November 15, 1902.

[This paper was written in German; the English translation, which was read at Washington and is here printed, while authorized by Professor Goebel, has not been revised by him.—ED.]

The Hypothesis of Formative Stuffs*

By T. H. Morgan

It is with some hesitation that I venture to discuss the hypothesis of formative stuffs as used by Professor Goebel in his Organographie and in his recent papers in the Biologisches Centralblatt. But since for all questions connected with the regeneration of plants it is of great importance to have a clear understanding of what this hypothesis really means, I hope that I shall be justified in entering into a discussion of this question, although the hypothesis is applied by its present adherents rather to plants than to animals. Professor Goebel uses the word correlation to give a name to certain curious, connected changes in different parts of the plant. Almost without exception when he ventures to express an opinion as to the cause of this connection, he makes use in one form or another of the Bonnet-Sachs hypothesis of formative stuffs. These stuffs are imagined to be either organized or unorganized substances that flow in different directions. The cause of this flow is sometimes ascribed to the polarity of the tissues; at other times to the attractive power for such substances that certain parts are supposed to possess. These alternatives are, I believe, fundamentally different conceptions.

I have made bold to question this hypothesis of formative stuffs.† More especially in the case of animals I have tried to show that there is little or no evidence in favor of such a view. In the case of plants I admit that under certain circumstances the presence or quantity of certain materials, especially food stuffs, may play a part in regenerative processes. But even in plants, despite the high authority by which the hypothesis is supported, I am sceptical whether formative stuffs are the chief factors in the result in those cases where polarity is involved. Let us examine the hypothesis more carefully. Bonnet suggested, in 1745, that the

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† Morgan, T. H. Regeneration, 88–90. 1901.

development of a head on one end of a piece of the worm, *Lumbriculus*, and of a tail on the other end of the piece, is due to fluids that flow forwards and backwards respectively, and act on head-germs at the anterior end of the piece, and on tail-germs at the posterior end. The accumulation of the head-stimulating fluid at the anterior end of the piece is supposed to awaken the germ of a head that lies at the anterior end. Conversely the tail-stimulating fluid, accumulating at the posterior end of the piece, awakens there the germs of the tail. It is unnecessary to point out that both the assumption of head- and tail-germs, and also the forward flow of certain kinds of substances, and the posterior flow of other kinds of substances are entirely fictitious assumptions, which from our modern point of view would be more difficult to account for than the phenomenon of regeneration itself.

Sachs made use of the same idea, but in a very different form. He thought that the development of shoot-buds and of root-buds depended on the presence of certain substances in the plant. In order to account for the development of the shoots at or near the distal end of the piece, and of roots at the proximal end, he further postulated that the shoot-forming substances flow upwards, and the root-forming substances downwards — in response to the action of gravity. Vöchting's careful and elaborate series of experiments showed that the results cannot be explained so simply. He believes that an inner organization, or polarity, is the main factor in determining the result. Later Sachs also laid more emphasis than he had done at first on this innate factor.

Goebel appears at times to advocate strongly the idea that the flow of substances in the plant is the cause of several of the phenomena of regeneration. At other times he applies the hypothesis in such a vague way and under so many forms, that depend on quite different principles, not clearly kept apart, that the explanation often appears quite confused.

In his account of his experiments with seedling plants he makes little use of the hypothesis. On the other hand, in his beautiful experiments with cuttings of the stem of *Bryophyllum* he speaks out strongly in favor of the view that the results can be best explained on the assumption of the flow of certain substances, or at least of their accumulation in the plant. He thinks that the results

of the experiments with the isolated leaves of the foliaceous liverworts can be best explained without assuming polarity, which in turn he here supposes to be associated with the absence of fibro-vascular bundles in the leaves. He ignores the well-known fact that in many of the algae, which are extremely simple in structure, the polarity is as strongly expressed as in the regeneration of the higher plants. Moreover, the unicellular animals and plants show well-marked polarity. At other times Goebel speaks of certain growing regions — apical buds or cells — as drawing on the general supply of certain substances, and by continually exhausting these inhibiting the growth of other buds less advanced or less fortunately situated. He does not, I believe, sufficiently discriminate between this possibility, and the other view of the direction of the flow itself determining the development of certain parts.

I shall try to keep apart the idea that the presence of some particular substance may be the immediate cause of the growth of a part, and the idea of the flow of particular substances in a given direction as the immediate cause of growth. Moreover, it will be well to discriminate between the two possible causes of the flow. The polarity itself is sometimes hinted at by Goebel as the cause that determines the direction of the flow. On the other hand we may suppose that the flow is always towards the region where less of the substance exists and from the region where more is present.

The theory of mobile stuffs was first invented to explain the phenomenon that we call polarity. It is especially this part of the theory that I contest. I do not deny that the presence of certain substances in a piece may determine its reaction, neither do I question that a flow of certain substances in definite directions in the plant takes place, but I suspect the real cause of the flow in a given direction is dependent on the presence of certain organs, where the substances are being used or changed into other substances. Let us take a specific case and make definite applications of these different points of view. If a piece of the stem of a willow-plant is cut off and suspended in a moist atmosphere (its leaves having been previously removed) with its apical end upward, it will be found that the buds near the upper end of the piece begin first to grow, and grow more rapidly than those below them.

The buds near the base of the piece may not develop at all. The reverse is true in regard to the roots. They appear only at the base of the piece.

On Sachs' original assumption the development of the leaf-buds at the upper end of the piece is due to the accumulation at the upper end of some substance that causes them to develop. The development of the roots at the lower end is supposed also to be due to the presence there of another kind of substance. Vöchting showed that when the piece is turned upside down practically the same result follows; namely, the shoot-buds develop at the distal end of the piece, which is now the lower, and roots at the proximal end which is now the upper. This and other experiments make it highly probable that external factors play a very subordinate rôle in the development.

Now Goebel, following Sachs, is also at times inclined to ascribe the results of this, or of similar experiments, to the flow of different substances in the piece in different directions, but the cause of the flow is now ascribed to an internal factor, namely, to the polarization of the tissues themselves. It is somewhat ludicrous to find that while the hypothesis of formative stuffs was first invented to explain the polarity of the piece, the polarity is now assumed in order to account for the flow of the stuffs. My first question then is this: Is there any evidence to show that the polarity of the piece determines the direction of the flow of substances in the piece? I should also like to ask, is there any evidence to show that after the removal of a piece the flow of substances in it continues in the same direction as when the piece was a part of the plant?

In the first place can we account for the regeneration of pieces of the stem by means of the presence of formative stuffs, without assuming them to flow in definite directions? Let us see where such an assumption will lead. We may assume that when the piece is cut off certain substances accumulate in it. The excess of these substances tends to start the development of the leaf-buds and root-buds. Let us further assume that those leaf-buds will begin to develop that are the youngest, and these will always be those nearer the distal end. As they develop they will, by using up the substances present, retard the development of the other

buds that are less developed. But in the case of the roots, the second assumption would have to be reversed, since those that develop are the oldest root-buds.

In this analysis I have attempted to give an explanation of the results without making use of the hypothesis of a directive flow of the formative stuffs, but it is clear that while the explanation may appear to hold for the shoots, it breaks down when applied to the roots; and, I believe, that whatever form the hypothesis takes it meets with inherent difficulties.

For example, let us take the application that Goebel has made in his attempt to explain the results of two different experiments with cuttings of begonia. He found that if his cuttings did not produce roots at the lower end of the stem, then the buds in the incisions of the leaves began to develop. He explains their development as due to the non-development of roots, and the consequent accumulation of some substance in the plant. But this will only account for the development of the roots of the plantlets on the leaves, and not for the leaves of the plantlets.

Conversely, he found by removing all the buds from a plant that the buds in the incisions of the leaf began to develop. This again he explains on the hypothesis that those substances that are generally used up by the growing points have accumulated, when these parts have been removed. This might appear to account for the development of the leaf-buds in the incisions of the leaves, but not for the rootlets. The hypothesis proves too much.*

My second question is this: May we not meet in these cases of regeneration with a phenomenon essentially similar to that which recent experimenters on the development of the non-fertilized animal egg have encountered? Contrary to the opinion first expressed, that the parthenogenetic development was due to the entrance of certain fertilizing ions into the egg, it has turned out that almost any kind of stimulus may start some eggs to develop. Such different kinds of things as salt-solutions, sugar, cold, heat, and even shaking will start the development of the egg of the star-fish. May this not be also the case with the piece of the plant? Will not any physical change affecting the germ start

*It is taken for granted here that the shoot- and root-forming substances are different.

its development? But if this is the case the difference in the behavior of the distal and proximal buds still remains to be accounted for, and this is the main point now under discussion. If we should be tempted to supplement the first assumption by making use once more of the idea suggested above in another connection, namely, that the youngest buds will be the first to develop, we should still, as we have already seen, get into a difficulty in regard to the roots.

I am of the opinion that the phenomenon of regeneration can not be explained by a purely chemical hypothesis. I suspect, at least, that certain physical conditions may be equally important. My meaning can be best illustrated by certain experiments that I have recently made with the tubularian hydroid, *Tubularia Mesembryanthemum*. This case is especially interesting in the present connection, because it is the only instance in modern times in which the hypothesis of formative stuffs has been applied to animals to explain regeneration. Moreover, hydroids react in many ways to external stimuli much like plants.

If long pieces of the stem of tubularia are cut off, and then the head or hydranth be removed from the distal end, it will be found that a new head develops in the course of twenty-four hours. This head appears at the distal end of the piece. After another twenty-four hours another head develops on the other, the proximal, end of the piece.

The stem as well as the hydranth-head of tubularia contains a red pigment. Before a new head develops at a cut end the same red pigment begins to appear in this region. Loeb suggested that this pigment is a formative stuff produced by the stem, and that its accumulation at the anterior end gives the stimulus for the formation of a new hydranth. Later Driesch also studied the regeneration of these pieces of tubularia, and observed that red pigment appears in great quantity in the fluid that circulates in the center of the piece. He thought that its presence might act quantitatively, and determine the kind of incomplete structures that short pieces of the stem often produce.

I have been able to prove that both of these suggestions are wrong, because in the first place the amount of pigment that develops in small pieces is much greater than that which was at first

present. Second, the amount in the stem does not decrease, while that at the end is increasing; and third, the red pigment of the circulating fluid disappears, not by going into the forming wall of the new hydranth, but by being collected into a ball in its stomach. Stevens has shown that this ball is later vomited from the mouth. Thus the pigment hypothesis of tubularia has been disposed of. Let us now consider the experiments that bear directly on my main theme. I have just pointed out that two heads develop on pieces of the stem of tubularia, one twenty-four hours after the other. This delay in the appearance of the proximal head would be interpreted on the stuff-hypothesis as due to the distal head, that first develops, using all the available hydranth-forming material. It can be shown that this cannot be the explanation. First, if a thread is tied around the middle of the piece the development of the distal hydranth is not delayed, but the development of the proximal hydranth is greatly hastened. Second, if a piece is simply bent, the proximal head will develop almost as soon as the distal one. Third, short pieces (if not so small that the usual kind of development is interfered with) produce distal heads as soon as do longer pieces; thus showing that the amount of material in a long piece is more than ample to allow a hydranth to develop at each end at the same time. Fourth, if the two ends of a long piece are allowed to close, and if then the piece is cut in two, the development of the distal hydranth is hastened. We may conclude from these experiments that the delay in the appearance of the proximal hydranth is not due to the direction of the flow of the formative substances, because when a long piece is simply cut in two the development of the proximal hydranth may be hastened. The delay is due, only in a very small degree, to the polarity, because if the piece is simply tied in the middle the development of the proximal hydranth is hastened. Neither can the delay be due to the amount of food-stuff available, because pieces much shorter than half of these long pieces produce distal hydranths as soon as do the longer pieces. The stuff-hypothesis fails to explain the facts from every point of view.

The results certainly suggest that some physical factor enters into the problem. It seems to me that whatever this physical factor may be, it is the same that we find acting wherever growth and the formation of new structures are taking place.

In my book, "Regeneration," I offered, as a pure conjecture, the suggestion that this physical factor expresses itself in the form of different tensions in the living tissues. Goebel asks whether such a conception puts the question in any clearer light than before. I am inclined to think that the idea is not entirely worthless, and it should not be forgotten that I pointed out, as emphatically as possible, that the view is only conjectural and must be tested by further work. It was offered as a possible working hypothesis, and it is unfair to treat the suggestion in any other light. If the view appears too vague it can be given a more practical form by assuming that the differences in tensions are simply the outcome or expression of osmotic changes, which are themselves in turn the result of the presence of certain chemical substances present, or being produced in the organism.*

BRYN MAWR COLLEGE.

* Since the above was written Matthews has suggested that my tension-hypothesis may be an expression of the electrical conditions in the piece; in short, that "polarity" is an electrical phenomenon; possibly, I may add, due to the movement of ions.

present. Second, the amount in the stem does not decrease, while that at the end is increasing; and third, the red pigment of the circulating fluid disappears, not by going into the forming wall of the new hydranth, but by being collected into a ball in its stomach. Stevens has shown that this ball is later vomited from the mouth. Thus the pigment hypothesis of tubularia has been disposed of. Let us now consider the experiments that bear directly on my main theme. I have just pointed out that two heads develop on pieces of the stem of tubularia, one twenty-four hours after the other. This delay in the appearance of the proximal head would be interpreted on the stuff-hypothesis as due to the distal head, that first develops, using all the available hydranth-forming material. It can be shown that this cannot be the explanation. First, if a thread is tied around the middle of the piece the development of the distal hydranth is not delayed, but the development of the proximal hydranth is greatly hastened. Second, if a piece is simply bent, the proximal head will develop almost as soon as the distal one. Third, short pieces (if not so small that the usual kind of development is interfered with) produce distal heads as soon as do longer pieces; thus showing that the amount of material in a long piece is more than ample to allow a hydranth to develop at each end at the same time. Fourth, if the two ends of a long piece are allowed to close, and if then the piece is cut in two, the development of the distal hydranth is hastened. We may conclude from these experiments that the delay in the appearance of the proximal hydranth is not due to the direction of the flow of the formative substances, because when a long piece is simply cut in two the development of the proximal hydranth may be hastened. The delay is due, only in a very small degree, to the polarity, because if the piece is simply tied in the middle the development of the proximal hydranth is hastened. Neither can the delay be due to the amount of food-stuff available, because pieces much shorter than half of these long pieces produce distal hydranths as soon as do the longer pieces. The stuff-hypothesis fails to explain the facts from every point of view.

The results certainly suggest that some physical factor enters into the problem. It seems to me that whatever this physical factor may be, it is the same that we find acting wherever growth and the formation of new structures are taking place.

In my book, "Regeneration," I offered, as a pure conjecture, the suggestion that this physical factor expresses itself in the form of different tensions in the living tissues. Goebel asks whether such a conception puts the question in any clearer light than before. I am inclined to think that the idea is not entirely worthless, and it should not be forgotten that I pointed out, as emphatically as possible, that the view is only conjectural and must be tested by further work. It was offered as a possible working hypothesis, and it is unfair to treat the suggestion in any other light. If the view appears too vague it can be given a more practical form by assuming that the differences in tensions are simply the outcome or expression of osmotic changes, which are themselves in turn the result of the presence of certain chemical substances present, or being produced in the organism.*

BRYN MAWR COLLEGE.

* Since the above was written Matthews has suggested that my tension-hypothesis may be an expression of the electrical conditions in the piece; in short, that "polarity" is an electrical phenomenon; possibly, I may add, due to the movement of ions.

The Genus Riella, with Descriptions of new Species from North America and the Canary Islands*

By M. A. Howe and L. M. Underwood

(With Plates 11 and 12)

The genus *Riella* occupies a unique position among the Hepaticae. The striking peculiarities of its gametophytic phase have attracted the attention of such morphologists as Hofmeister, Leitgeb, and Goebel, in addition to the interest excited among those who have devoted themselves more exclusively to a study of the systematic relations of the Hepaticae. *Riella helicophylla*, an Algerian species, is alluded to in some of the standard botanical text-books as being peculiar among the liverworts in having a leaf-like lamina or wing disposed spirally in relation to the axis or stem. Later studies of this species, however,† indicate that the supposed helicoid spiral arrangement was exaggerated in the original figures and description and that the spiral appearance is due to the slight torsion of a stem bearing a strongly undulate lamina. Nevertheless, the species of *Riella* in general are peculiar enough in that the lamina or wing appears at first sight to be attached to one side of the stem; but the position of the sexual organs, of the root-hairs and of the scale-like appendages shows that the plant is bilaterally symmetrical in the plane of the wing and the conviction is now general that the wing is dorsal in relation to the stem. Goebel‡ has expressed the opinion that the chief difference between *Riella* and the other liverworts is that in *Riella* the development of the thallus is in the vertical instead of in the horizontal plane. The species of *Riella* are all aquatic, commonly growing entirely submerged, and it is doubtless this condition of growth which makes possible the leading peculiarity in form.

The growing point of a young plant or of a young branch of

* Read in abstract before the Botanical Society of America, Ninth Annual Meeting, Washington, D. C., December 31, 1902.

† Trabut, Rev. Gén. Bot. 3: 451. 1891. Stephani, Bull. Herb. Boiss. 7: 659. 1899.

‡ Flora, 77: 107. 1893.

Riella is not apical in the ordinary sense of the word, but intercalary. The whole tissue of the young shoot appears to be meristematic at first and of one layer of cells. Later, the growth activities are concentrated at either one or two points on the margin of the shoot intermediate between its distal and proximal extremities. If at *two* points, these are situated on opposite margins of the shoot. The new cells formed on the upper or distal side of the growing point now contribute to the growth of the unistratose wing, which is dorsal in position. The new cells formed on the lower or proximal side of the growing point go to constitute the multistratose stem, which is ventral in position. If two growing points on opposite margins of a young shoot persist, a double or twin plant is formed, the two branches of the axis bearing a single continuous dorsal wing. If, however, only one growing point persists, the plant or branch is apparently one-sided, with stem on one side and wing on the other, though in reality the wing is dorsal and the stem ventral.

On account of the absence of elaters, *Riella* was at first placed with the Ricciaceae, together with *Sphaerocarpus*, in which, likewise, elaters are not developed. A better understanding of the morphology of these two genera has led to placing them in the order Jungermanniales, of which, together with the exclusively American genus *Thallocarpus*, they constitute the simplest members. The genus *Riella* forms the subfamily Rielloideae and in the usual arrangement stands between the Sphaerocarpoideae and Metzgerioideae in the family Metzgeriaceae (the Jungermanniaceae anakrogynae of Leitgeb and Schiffner).

The geographical distribution of this strongly characterized genus *Riella* is of interest. Up to within a few months ago, the genus was supposed, as far as the literature on the subject is concerned, to be confined to the Mediterranean drainage basin of Africa and Europe, with seven species, as commonly recognized. One of these, however, *Riella Gallica*, was reduced by M. Corbière in the last number of the Revue Bryologique for 1902 to forma *Gallica* of the Algerian *R. Battandieri*. To these seven known species, or six, as now conceived, another from a region far removed was added by Morten P. Porsild in a recent number of the Botanisk Tidsskrift, where *R. Paulsenii* from Turkestan was

described and figured. References to the principal literature dealing with the genus, together with the names and distribution of the species hitherto described, are given below:

RIELLA Mont. Ann. Sci. Nat. III. **18**: 11. 1852. Leitgeb, Untersuch. Leberm. **4**: 74–87. *pl. 7, 8. f. 1–8.* 1879. Trabut, Rev. Gén. Bot. **3**: 449. 1891. Goebel, Flora, **77**: 104–108. *pl. 2. f. 1–3.* 1893. Schiffn.; E. & P. Nat. Pflanzenfam. **1**[3]: 51. 1893. Stephani, Bull. Herb. Boiss. **7**: 658. 1899.

Duriaea Bory & Mont. Compt. Rend. Hebd. Acad. Sci. **16**: 1115. 1843; Ann. Sci. Nat. III. **1**: 228. 1844. G. L. & N. Syn. Hep. 593. 1846. Not *Durieua* Mérat, Mém. Soc. Roy. Sci. Lille, **1827–28**: 432. 1829. Not *Durieua* Boiss. & Reut. Diag. Pl. Nov. Hisp. 14. 1842.

Maisonneuvea Trevis.* Mem. R. Ist. Lomb. III. **4**: 442. 1877.

Duriella Clauson & Billot, *fide* Schiffn., *l. c.*

RIELLA BATTANDIERI Trab. Rev. Bryol. **13**: 35. *pl. 3.* 1886. Schiffn. Bot. Centralb. **27**: 240. *pl. 1. f. 5.* 1886.

ALGERIA: Maison-Blanche near Algiers, *Battandier, Trabut.*

EXSICC.: Husnot, Hep. Gall. no. 173.

Forma GALLICA (Bal.) Corbière, Rev. Bryol. **29**: 113. 1902.

Riella Gallica Bal.; Trab. Rev. Gén. Bot. **3**: 450. *pl. 18. f. G.* 1891.

FRANCE: Roquehaute, near Béziers, Hérault, *Balansa*, 1866, *Crozals*, 1902; mare de Rigaud near Agde, Hérault, *Crozals*, 1902.

RIELLA COSSONIANA Trab.; Batt. & Trab. Atlas Fl. Alg. **1**: 6. *pl. 2. f. 1–8.* 1886; Rev. Bryol. **14**: 12. *pl.* 1887.

ALGERIA†: El Kreider, Province Oran, *Cosson*, 1854; *Trabut*, 1885.

EXSICC.: Husnot, Hep. Gall. no. 174.

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* Trevisan rejected *Riella* Mont. on account of *Riella* Raf.; Lév.; Orb. Dict. Univ. Hist. Nat. **8**: 488. 1849. This, however, is a *nomen nudum* and is probably a misprint for *Rimella* Raf. Jour. Phys. **89**: 106. 1819.

† Allusions to the occurrence of *Riella Cossoniana* in the Canaries have recently appeared in print (Bot. Tidsskrift, **24**: 327. 1902; Rev. Bryol. **29**: 110. 1902), but it is possible that these refer to *Riella affinis*, described below as new.

RIELLA HELICOPHYLLA (Bory & Mont.) Mont. Ann. Sci. Nat. III. **18**: 12. 1852; Syll. Gen. Sp. Crypt. 94. 1856.

Duriaea helicophylla Bory & Mont. Compt. Rend. Hebd. Acad. Sci. **16**: 1116. 1843; Ann. Sci. Nat. III. **1**: 229. 1844. G. L. & N. Syn. Hep. 593. 1846. Mont.; Bory & Durieu, Expl. Sci., Algérie, Bot. *pl. 34.* 1846–49.

ALGERIA: Province Oran, *Durieu*, *Trabut.*

EXSICC.: Husnot, Hep. Gall. no. 172.

RIELLA NOTARISII (Mont.) Mont. Ann. Sci. Nat. III. **18**: 12. 1852; Syll. Gen. Sp. Crypt. 94. 1856.

Sphaerocarpus Notarisii Mont.; De Not. Mem. R. Accad. Torino, II. **1**: 343. *f. d. 1–8.* 1839.

Duriaea Notarisii Bory & Mont. Compt. Rend. Hebd. Acad. Sci. **16**: 1116. 1843; Ann. Sci. Nat. III. **1**: 229. 1844. G. L. & N. Syn. Hep. 593. 1846.

SARDINIA: near Pula, *De Notaris*, 1834.

GREECE: Phalerus, *Chaboisseau*, *fide* Stephani.

RIELLA PARISII Gottsche; G. & R. Hep. Eur. no. 375. 1867. [Illust.] Leitgeb, Untersuch. Hep. **4**: 76. *pl. 7. f. 17.* 1879. Stephani, Bull. Herb. Boiss. **7**: 661. 1899.

Riella Clausoni[*s*] Letourneux; Husnot, Hepaticologia Gallica, 87. *pl. 12. f. 151.* 1881. Batt. & Trab. Atlas Fl. Alg. **1**: 13. *pl. 8.* 1886. Trab. Rev. Gén. Bot. **3**: 452. 1891.

ALGERIA: Maison-Carrée, etc., near Algiers, *Clauson*, *Paris*, *Trabut.*

EXSICC.: G. & R. Hep. Eur. no. 375; Husnot, Hep. Gall. no. 121.

RIELLA PAULSENII Porsild, Bot. Tidsskrift, **24**: 323–327. *f. 1–3.* 1902.

TURKESTAN: Bokhara, *Paulsen*, 1898.

RIELLA REUTERI Mont. Ann. Sci. Nat. III. **18**: 12. 1852. Hofmeister, Bericht. Verh. Kgl. Sächs. Gesellsch. Wiss. 1854: 92–95. *pl. 4.*

SWITZERLAND: near Geneva, *Reuter*, 1851.

In describing *Riella Paulsenii*, the first species of the genus known to occur outside of the Mediterranean region, Porsild expresses the surmise that the distribution of the genus may prove to be still more widely extended, which is well verified by the known existence at the present time of three specimens of *Riella* collected within the boundaries of the United States. One of these, strangely enough, was collected by Schott as long ago as 1855, but has remained unstudied and unnoted in literature. In April, 1902, western Texas, the region from which Schott's specimens came, was visited by Professors F. S. Earle and S. M. Tracy, who secured further specimens which we consider the type of the well-marked species described below:

Riella Americana sp. nov.

Erect or ascending, 10–30 mm. high, simple or more commonly 1–4 times furcate: axis elliptical in section, 0.2–0.8 mm. wide, mostly 6–10 cells thick, root-hairs borne only on the basal parts and usually few: wing 2–5 mm. broad, rounded-falciform at apex, slightly undulate-crisped, subentire or erose, tapering toward the base and commonly deficient below the first dichotomy; cells near the axis about 60 μ in greatest diameter, those near the margin about 40 μ: scales few, small, 0.2–0.6 mm. long, linguiform and obtuse or irregularly lanceolate and subacute, those near the growing apex usually intermingled with multicellular gemmae: gemmae trichomic in origin, soon oblong or orbicular-oblong in outline, showing later a median constriction and becoming finally panduriform and subspatulate: dioicous: antheridia about 0.36 × 0.16 mm., sometimes as many as 75 (including empty loculi) in a single elongated marginal series: ♀ gametophyte, or each of its branches, maturing for the most part 3–12 sporogonia in acropetal order: involucres smooth, ellipsoidal-ovoid or at full maturity subglobose-ovoid, 1.4–1.8 mm. × 0.8–1.2 mm., narrowed rather gradually to the truncate or slightly pointed subpapillose orifice: capsule globose, 0.8–1 mm. in diameter, seta about 0.2 mm. long, mostly a trifle shorter than the ovoid-conic foot: spores dark-brown, 100–130 μ in maximum diameter (spines included); outer face bearing numerous sometimes curved spines 10–24 μ long, with dilated apices, these spines more or less connected by radiating basal membranes forming irregular reticulations; inner faces bearing conical, non-capitate spines, 3–6 μ long, with basal membranes obsolescent or entirely wanting. (*Pl. 11; pl. 12, f. 21, 22*).

Limpia Cañon, Texas, F. S. Earle and S. M. Tracy, April 25, 1902, no. 251; this, the type specimen, is deposited in the her-

barium of the New York Botanical Garden. The plants are said by Professor Earle to have been found in a pool headed by a small waterfall, forming mats on rocks and stones which were covered by 10–60 cm. of water in the dry season. The same species was collected by Schott in 1855, his specimen originating from "Limpia, near its head, Western Texas." His plants, though otherwise agreeing perfectly with those of the more recent collection, are considerably smaller and are mostly unbranched. A *Riella* (in herb. A. W. Evans) was collected by Mr. De Alton Saunders at Brookings, South Dakota, in 1898. The material is scanty and the sporogonia are so immature that the spore-characters cannot be determined. The involucres and scales are similar to those of *R. Americana* and it is quite probable that the species is the same. This South Dakota specimen marks the northern limit in the known distribution of the genus.

Riella Americana is easily distinguished from any of the species hitherto known. Its nearest ally is probably *Riella Battandieri* f. *Gallica*, of southern France, which differs in being monoicous,* in the narrower wing, the smaller spores, with shorter non-capitate spines, etc. Gemmae have not before, to our knowledge, been definitely described in any species of *Riella*, though Goebel (Flora, **77**: 105. 1893) in figuring three young stages of *Riella Battandieri* (?) remarks in a footnote that one of them sprang from a "Zellkörper" while the others came from "Zellfäden." By analogy with what we have observed in *Riella Americana*, it seems very probable that his plant from the "Zellkörper" came from a brood-body of some kind, while those from the "Zellfäden" were derived from spores. The young plants of *Riella Cossoniana*, represented by Trabut in his figures 1 and 2 (*l. c.*), also, with little doubt, originated from gemmae. The gemmiform appendages figured by Trabut on the axis of his *R. Gallica* are of a more doubtful nature. These were not found by Corbière in his recent studies of what he believes to be the same species; possibly they were designed to represent remains of old involucres and sporogonia.

The gemmae of *R. Americana* originate on the axis as trichomic outgrowths, each of about three cells in a single series (*f. 10, 11*) of which the terminal cell is usually the largest. The two

* Corbière, Rev. Bryol. **29**: 111, 113. 1902.

lower cells then divide in the sagittal plane (*f. 11*) and this this is followed by a division of the terminal cell. The basal cells afterward grow out and divide in such a way as to give the body a free margin throughout its periphery, though it remains attached to the axis for a considerable time by a single cell on its proximal surface. *F. 13–16* show stages in the subsequent development, *14* being a view of its proximal surface, and *13*, *15* and *16* of its distal, the point of attachment in each case being at *b*. The part which is derived from the base of the original trichome consists soon of cells which are smaller, richer in protoplasm, and capable of more rapid division than those of the part which is derived from the apex of the original trichome. This part of basal origin is more regularly suborbicular in outline than the other. In neither part can an apical cell be pointed out with any certainty. In the earlier stages the whole body seems to be meristematic; later a constriction appears near its middle and the formation of new cells is then the most active in the zone of this constriction. The larger-celled part, derived from the apex or distal end of the initial trichome, becomes at about this time more than one cell thick in its middle and terminal regions and shows papilliform outgrowths, the beginnings of the root-hairs. The smaller-celled portion derived from the base or proximal end of the initial trichome remains only one cell thick except in the isthmus of constriction where it finally, in part at least, becomes two or more cells thick. *F. 16* shows a well-developed gemma inverted as regards its original relations to the axis of the gametophyte. The edges of the two parts here overlap slightly in the zone of constriction. Later, the isthmus elongates, giving the body a somewhat panduriform or at length subspatulate outline. *F. 17* shows the outline of a gemma in an older stage, and *f. 18* a still later development.

Attempts to germinate the spores of the plants collected by Earle and Tracy were made in the autumn and winter of 1902–03. Though the spores were to all appearances mature, the attempts were successful in the case of only a very few spores, which were carried a little beyond the stage represented in our *f. 21* and *f. 22*. The germ-tubes in every case observed came out from near the middle of the outer or more spiny face. This tube is first

divided by transverse walls into a single row of several cells, three or four of the terminal of which are then divided by median longitudinal walls. This divided terminal portion by growth and multiplication of its cells becomes ovate or spatulate in outline. In the latest stage that we have been able to see, one somewhat more advanced than that represented in our *f. 21*, the whole body still consists of only one layer of cells. *F. 22* shows in edgewise view the same plant that is shown in *f. 21*. A root-hair is sent out from the spore soon after the emergence of the germ-tubes.

A second species of *Riella*, apparently new, from the Canary Islands, has come to our attention; this we would describe as follows:

Riella affinis sp. nov.

Apparently erect or ascending, becoming prostrate on the subsidence of the water, 6–15 mm. high, densely caespitose, simple or sparingly furcate: axis flattened, 0.1–0.4 mm. wide, mostly thin and flaccid, radicelliferous at base: wing 1–3 mm. broad, rounded or obtusely pointed at apex and falciform, deeply lobed; cells near the axis 45–60 μ in diameter, those near the margin about 30 μ: scales usually inconspicuous, 0.2–0.5 mm. long, linguiform, lanceolate, or linear, obtuse or acute: monoicous: antheridia solitary or in groups of 2–7 in more or less profound marginal sinuses: sporogonia mostly 3–10: involucres ovoid, 8-winged, 1.4–2 mm. long, 1–1.5 mm. wide (incl. wings), much contracted and often subacute at mouth; wings 0.1–0.2 mm. broad, with undulate-sinuate or subentire margin: capsule subglobose, 0.8–1 mm. in diameter, seta 0.1–0.2 mm. long: spores brown, 85–120 μ in maximum diameter (spines included); outer face densely covered with spines 6–15 μ long, their apices mostly truncate, often slightly dilated, occasionally emarginate-bifid, rarely acute, the supporting basal membranes sometimes almost deficient but commonly forming a few imperfect areolae; inner faces with mostly truncate or obtuse spines or warts 3–6 μ high, basal membranes wanting. (*Pl. 12. f. 23–36.*)

On the bank of a reservoir, Tafira, Grand Canary, June, 1897, O. F. Cook (no. 729). We are informed by the collector that the specimens were found partly submerged and partly exposed on a sloping bank.

Riella affinis is allied to the Algerian *R. Cossoniana* Trabut and the central Asian *R. Paulsenii* Porsild, but differs from both in being monoicous and in the much longer spines of the larger

spores. The involucres are less globose and more pointed at the apex than those of *R. Cossoniana*. Judging from two specimens of *R. Cossoniana* collected by Professor Trabut, *R. affinis* has the appearance of being a larger species with broader lamina, though this might not appear from a comparison of the measurements given above with those given by authors for *R. Cossoniana*. Our specimens of *R. affinis* are prostrate and more or less entangled with mud and are so delicate and fragile that it is quite possible that the measurements in the above description may fail to do full justice to the height of the plant. It may be remarked that in occasional capsules the spores though showing a well-developed brown coloration have short spines or papillae much like those of *R. Cossoniana;* such spores are always smaller than is normal for the species and are probably immature or else have ripened under abnormal conditions.

Our experiments in germinating the spores of *Riella affinis* have been more successful than those with the spores of *Riella Americana*, though they were not begun until December, 1902, five and a half years from the date of collection of the specimens. More than half of the spores experimented with germinated in a few days by being placed on a piece of wet filter-paper in a glass dish kept in a moist chamber at ordinary living-room temperatures. The germ-tube in practically all cases emerges, as in *R. Americana*, from the outer or more spiny face of the spore, usually near its middle. The root-hair follows a little later, its lumen remaining continuous with that of the germ-tube. The length of the germ-tube varies exceedingly. Finally, there appears in it a somewhat curved transverse wall with its convexity turned toward the spore. The part above contains most of the starch grains and in the course of time begins to show chlorophyll, cell-divisions meanwhile taking place as described above for *R. Americana*. The length of the germ-tube from the spore-wall to the curved septum has been observed to vary in different cases from 0.02–0.7 mm. One or two root-hairs, in addition to the one which comes from the base of the germ-tube, may spring out later from some part of the filamentous stalk of the young gametophyte. The forms assumed by the young gametophytes are extremely varied and are doubtless determined to a considerable extent by the conditions of

illumination, though no exact investigations were undertaken to demonstrate the influence of light in this matter. The prevailing form, however, while still unistratose, is spatulate, though flabelliform and linear outlines are not uncommon and grotesquely lobed and branched stages are often met with. Linear or ribbon-shaped forms, like that shown in *f. 36*, are especially common when the young plants are from the first well covered with water. Just below the chief growing point *c*, in the stage illustrated by *f. 34*, there are cell divisions in the plane of the paper, which possibly foreshadow the axis or stem, though they may have arisen in this case through changed relations to the light. We have not yet been able to follow the development much beyond this point, but we have grounds for believing that the subsequent history is essentially as described by Goebel (*l. c.*) for young plants of *A. Battandieri* with the exception that the wing is probably more lobed than in that species. In most cases, the development is confined to practically a single plane, though occasionally, as in the case represented by *f. 35*, the wing-lobes show an irregularly spiral arrangement, due perhaps to changed positions in regard to the light.

Explanation of Plates

[The drawings have been prepared by M. A. Howe, chiefly with the aid of a camera lucida.]

PLATE 11. *Riella Americana* Howe & Underw.

1 and 4. ♂ gametophytes, natural size.

2 and 3. ♀ gametophytes, natural size.

5. Terminal portion of a branch of the ♂ gametophyte, with a young branch at the apex, × 11.

6. Terminal portion of a branch of the ♀ gametophyte, × 11.

7. An involucre, with mature sporogonium, × 16.

8. A scale, × 55.

9. Portion of axis near the apex, showing gemmae and scales, × 40. The gemmae are shown at *a* and below; the scales are, in this case, nearer the wing.

10–18. Stages in the development of the gemmae. See text, pp. 219 and 220.

10. A trichome destined to become a gemma, in distal (outer) aspect, × 193.

11. A similar stage in lateral view, × 193.

12–15. Later stages; 12, 13, and 15 in distal aspect, 14 in proximal, × 193; *b*, point of attachment.

16. A more advanced stage inverted as regards its original relations to the axis and as regards the preceding figures, × 193.

17. Outline of a gemma in a later stage, × 55.

18. A young gametophyte derived from a gemma, × 28.

19 and 20. Spores, outer and inner faces, × 305.

Figures 4, 18–20, are drawn from material collected by Schott in 1855; the others from material collected by Earle and Tracy, April, 1902.

PLATE 12

Figs. 21 and 22, *Riella Americana* Howe & Underw.; Figs. 23–36, *Riella affini* Howe & Underw.

21. Germ plant, × 245.

22. Same in edgewise view, × 245.

23. Gametophyte of *Riella affinis*, × 11.

24. Apical portion of another, with involucres and antheridial loculi, × 11.

25 and 26. Involucres, × 16.

27 and 28. Spores, outer and inner faces, respectively, × 330.

29 and 30. Germinating spores, × 55.

31. Germ plant, showing the earlier cell divisions, × 245.

32–36. Various forms assumed by the germ plants, × 55. The principal vegetative point is indicated by *c*. The elongate form represented in Fig. 36 is common when the young plants are well covered with water.

The Polyporaceae of North America.—III. The Genus Fomes

By William Alphonso Murrill

The generic name *Fomes* is usually accredited to Fries, but this author never employed it to designate a genus. In Novae Symbolae, 46, 1851, the genus *Polyporus* is subdivided into *Eupolyporus* and *Fomes*, the latter division being described as follows:

"Pileus primitus lignoso-induratus (raro molles, plorantes), contextu floccoso intertexto, crusta rigida obductus, azonus, sed demum concentrice sulcatus. *Fungi perennes* (*vulgo stratose*), *reviviscentes, sed stratum annuum vegetum tantum est.*"

In listing species Fries wrote the word *Fomes* in parenthesis after *Polyporus*.

Gillet (Champ. France, 1: 682. 1878) raised *Fomes* to generic rank and described the group as follows:

"Hyménium poreux; pores non séparables entr'eux, distincts du chapeau, disposés par couches stratifiées. Espèces ligneuses-subéreuses, stipitées, dimidiées ou résupinées, recouvertes d'une croûte dure, épaisse et st. marquée de zônes annuelles séparées par des sillons concentriques. Champignons vivaces à accroissement indéfini."

Under this genus Gillet lists thirteen species, the first being *F. marginatus*, which is therefore considered its type. Most of the remaining species of *Fomes*, as the term is used in Saccardo's Sylloge, were assigned to this category by Cooke in Grevillea (v. 13 and 14, 1884–85). Karsten was the first to divide generically this large group of perennials, which now comprises a half dozen or more genera, the name *Fomes* being connected with the natural subdivision to which *F. marginatus* belongs. Karsten's name *Fomitopsis*, applied to this subdivision in 1881, unfortunately becomes a synonym of *Fomes*. His names *Ganoderma* and *Elfvingia*, however, hold for other important subdivisions.

Synopsis of the North American Species

1. Context white or yellowish. 2.
   Context flesh-colored, pileus often effused or effused-reflexed, flesh-colored, soon blackening, tubes round, 3–4 to a mm. 1. *F. roseus.*
2. Pileus over 3 cm. broad. 3.
   Pileus less than 3 cm. broad. 8.
3. Pileus encrusted, surface darker than the context. 4.
   Pileus rarely encrusted, surface concolorous with the context. 9.

4. Pileus thick, sulcate, ungulate, rarely applanate. 5.
Pileus at first thin, triangular or lobed, shining reddish-chestnut above, becoming dimidiate, ungulate at the center, and dull brown: spores ovoid, 3.5 × 5 μ. Pileus attached by a lateral stipe which soon disappears. 7. *F. stipitatus.*
Pileus thin, distinctly zonate, irregular or applanate, crust brown to black: spores ovoid, hyaline, 6 × 4 μ. 2. *F. annosus.*

5. Surface not soon rimose, older pores not visible. 6.
Surface soon becoming rimose, deeply sulcate, older pores visible in the upper projecting annual layers: pileus exactly ungulate, found only on *Shepherdia*. 4. *F. Ellisianus.*

6. Pores 4–5 to a mm. 7.
Pores 2–3 to a mm.: pileus subtriangular, gray to black, context white to pale cinnamon: spores ellipsoidal, 7–8 × 6–7 μ; abundant on *Fraxinus*. 5. *F. fraxinophilus.*

7. Pileus applanate, many times sulcate, horny encrusted, extremely hard in substance; tropical. 6. *F. ligneus.*
Pileus ungulate, applanate when very large, deeply annually sulcate, surface often resinous, bay or black in color; abundant on coniferous trees in temperate regions. 3. *F. ungulatus.*

8. Pileus ungulate, becoming black only at the base, zonate and concentrically sulcate in age, tubes over 0.2 cm. long. 8. *F. Ohiensis.*
Pileus scutellate, uniformly black when quite young, tubes less than 0.2 cm. long, context thinner than tube-layer. 9. *F. scutellatus.*

9. Pileus cylindrical, tubes long, visible at edges of older strata, context friable, becoming bitter; growing on conifers. 10. *F. Laricis.*
Not as above. 10.

10. Pores large, 2 to a mm., becoming reddish when bruised, annual strata separated by thick layers of context; tropical. 13. *F. rubritinctus.*
Pores small, 5–7 to a mm., not changing to reddish when bruised. 11.

11. Tubes less than 2 mm. long each season, context punky, hymenium glistening, not becoming dark in color. 11. *F. populinus.*
Tubes more than 2 mm. long each season, context hard and rather friable, hymenium becoming smoky or brownish, cracking in age. 12. *F. Meliae.*

1. FOMES ROSEUS (Alb. & Schw.) Cooke

Boletus roseus Alb. & Schw. Consp. Fung. 251. 1805.

Polyporus roseus Fr. Syst. **1**: 372. 1821.

Polyporus carneus Nees, Nov. Act. Nat. Curios. **13**: *pl. 3.* 1827.

Fomitopsis rosea Karst. Rev. Myc. **3**: 18. 1881.

Fomes roseus Cooke, Grevillea, **14**: 19. 1885.

Fomes carneus Cooke, Grevillea, **14**: 21. 1885.

This fungus is very widely distributed and does serious injury to various coniferous trees both in Europe and America. Its form varies greatly with the character of the host plant. Besides the names mentioned above, *P. rufo-pallidus* Trog (Flora, **15**: 556.

1832. Fries, Icon. *pl. 186. f. 1*) doubtless refers to the same plant and I have a suspicion that *Polystictus arcticus* Fr. is also a synonym, since plants at Kew collected near Carlton in May, 1858, are only grayish zonate forms of *F. roseus*. The actual types of *P. arcticus* I have not seen.

A few of the collections examined are here listed: Finland (Karsten), Canada (Macoun, Dearness), Maine (Miss White), Newfoundland (Waghorne?), New Hampshire (Minns, Underwood), Ohio (James), New Jersey (Ellis), Colorado (Bethel, Pammell), West Virginia (Nuttall), Washington (Piper), Florida (Calkins), Nebraska (Kennedy), South Carolina (Ravenel), Alabama (Peters), California (McClatchie), Connecticut (Underwood), Georgia (Underwood).

2. FOMES ANNOSUS (Fr.) Cooke

Polyporus annosus Fr. Syst. **1**: 373. 1821. Icon. *pl. 186. f. 2.*

Polyporus serpentarius Pers. Myc. Eur. **2**: 82. 1825.

Polyporus subpileatus Weinm. Fl. Ross. 332. 1836.

Polyporus resinosus Rostk.; Sturm, Deutsch. Fl. **4**: 61–62. *pl. 29.* 1838.

Trametes radiciperda R. Hartig, Wicht. Krankh. Waldb. 62. 1874.

Fomitopsis annosa Karst. Rev. Myc. **3**: 18. 1881.

Fomes annosus Cooke, Grevillea, **14**: 20. 1885.

Heterobasidion annosum Bref. Untersuch. **8**: 154. *pl. 9.* 1889.

Polyporus irregularis Underw. Bull. Torrey Club, **24**: 85. 1897.

Kreiger 121, Romell 13, Sydow 3107, 1108, 504, Allescher & Schnabl 137, 432, Roumeguère 3111, 7248, Rabenhorst 405, de Thümen 106, Kunze 1, Briosi 2, Cavara 324. Sweden (Murrill), Tyrol (Bresadola), California (Harkness), Oregon (McBride), West Virginia (Nuttall), Pennsylvania (Gentry), Alabama (Earle, Baker, Woodward), Florida (Gory).

Many other specimens have been examined, but the above-mentioned are sufficient to show that the plant is of wide distribution. It is particularly injurious to various species of coniferous trees.

3. FOMES UNGULATUS (Schaeff.) Sacc.

Boletus igniarius Scop. Fl. Carn. ed. 2. **2**: 469. 1772. Not *B. igniarius* L. 1753.

Boletus ungulatus Schaeff. Fung. Bav. **4**: 88. *pl. 137, 138.* 1774.

Boletus fulvus Schaeff. Fung. Bav. **4**: 89. *pl. 262.* 1774.

Boletus semiovatus Schaeff. Fung. Bav. **4**: 92. *pl. 270.* 1774.

Boletus marginatus Pers. Obs. **2**: 6–7. 1799.

Boletus pinicola Sw. Vet. Akad. Handl. 88. 1810.

Polyporus marginatus Fr. Syst. **1**: 372. 1821.

Polyporus pinicola Fr. Syst. **1**: 372. 1821.

Fomes marginatus Gill. Champ. Fr. **1**: 683. 1878.

Fomitopsis pinicola Karst. Rev. Myc. **3**: 18. 1881.

Fomes pinicola Cooke, Grevillea, **14**: 17. 1885.

Fomes ungulatus Sacc. Sylloge, **6**: 167. 1888.

A large and widespread species growing abundantly on coniferous trees, such as the hemlock and pine, and found more rarely upon deciduous trees standing near its usual hosts. Beech, elm, maple and birch are known to have been attacked by it in American and European forests where conifers abound. Fresh specimens collected on fir trees in Sweden correspond in all respects with Schaeffer's *B. ungulatus*, so I do not hesitate to use his name. Collections showing the range of this plant are as follows: Saxony (Krieger 13), Sweden (Romell 116, Murrill), Siberia (de Thümen 1906), France (Roumeguère 2205), Bohemia (de Thümen 814), Hungary (Linhart 250, 446), Canada (Macoun), New Hampshire (Minns), New York (Atkinson, Underwood, Murrill), Colorado (Crandall, Cockerell), West Virginia (Nuttall), Michigan (Wood), Maine (Ricker), Virginia (Murrill).

4. FOMES ELLISIANUS Anders.

Fomes Ellisianus Anderson, Bot. Gaz. **16**: 113. *pl. 12.* 1891.

Fomes circumstans Morgan, Jour. Cincinnati Soc. Nat. Hist. **18**: 37. *pl. 1. f. 4.* 1895.

This species was described from plants collected by Anderson in Montana during the summer of 1889. Its only host thus far reported is *Shepherdia argentea* Nutt., on the living trunks and branches of which it is very abundant in the Teton Valley.

Morgan's description is based on a collection in Dakota by T. A. Williams from the same host. His name refers to the half-encircling habit of the plant when it grows upon a branch. The fungus has also been collected in Colorado.

5. FOMES FRAXINOPHILUS (Peck) Sacc.

Polyporus fraxinophilus Peck, N. Y. State Mus. Rept. **35**: 136. 1882.

Fomes fraxinophilus Sacc. Sylloge, **6**: 172. 1888.

Ohio (Morgan, Gentry), Kentucky (Kellerman, Price), Missouri (Demetrio), Kansas (Bartholomew), Nebraska (Bates), Pennsylvania (Martindale), Iowa (McBride), Indiana (Underwood), New York (Peck).

This species is confined to the ash, on which it is very common. It has been confused with *P. fraxineus* (Bull.) Fr. by Cooke and some other mycologists. Anderson's no. 537 in the Parasitic Fungi of Montana was distributed under the name of *P. fraxinophilus* before it was described as *Fomes Ellisianus*.

6. FOMES LIGNEUS (Berk.) Cooke

Polyporus ligneus Berk. Ann. Nat. Hist. **3**: 387. 1839.

Fomes ligneus Cooke, Grevillea, **13**: 119. 1884.

Excellent specimens were collected in Nicaragua by C. L. Smith and in St. Kitts by Britton and Cowell. Plants from Mauritius at Kew bearing this name are specifically distinct from our fungus. *Fomes sulcatus* Cooke from Demarara is nearly allied to *F. ligneus*.

7. **Fomes stipitatus** sp. nov.

A plant of medium size with short evanescent lateral stipe, shining reddish-chestnut crust and broad white thin margin. Pileus exceedingly hard and horny, flat and triangular or somewhat circular when young, becoming dimidiate with ungulate center and thin spreading margin, which is usually lobed and often deeply cleft; hymenium normally plane, but frequently convex because of the upturned margin, 5 × 10 × 3 cm.; surface glabrous, varnished, reddish-chestnut, with numerous shallow concentric furrows, becoming shining black and at length dull smoky-brown; margin broad, flat, glabrous, obtuse, 3 mm. thick, crenate to cleft, sterile portion 0.5 cm. wide, white: context hard, woody, 0.5–1 cm. thick, pale ochraceous, with strands of dark-brown shining

horny substance extending from the stipe to the margin in a tree-like fashion: tubes plainly though unevenly stratified, 2–4 mm. long each season, 4–5 to a mm., grayish-brown within, mouths circular, white or very pale yellow, dissepiments thick, obtuse, entire: spores broadly ovoid with attenuate base, light yellowish-brown, smooth, 3.5 × 5 μ: stipe lateral, 1 × 1 cm., cylindrical, equal, glabrous, shining black to dull brown, with substance like the context, apparently absorbed or overgrown as the pileus enlarges.

This very distinct and easily recognized species was collected by C. L. Smith and B. Shimek in Nicaragua during the winter of 1891–92. Its conspicuous varnished surface and lateral stipe suggest at once the genus *Ganoderma*, but more important characters connect it with *Fomes* and I have with some hesitation assigned it to this genus, recalling the fact that *Fomes ungulatus* often has considerable varnish on its surface and that an umbo often has its beginning in a reduced stipe.

8. **Fomes Ohiensis** (Berk.)

Trametes Ohiensis Berk. Grevillea, **1**: 66. 1872.

This plant is unusually small for the genus *Fomes*, making with *F. scutellatus* a rather distinct subgroup. It grows upon rails and dead branches of various deciduous trees. Among collections examined are those from Canada (Dearness), Kansas (Cragin), Michigan (Dennen), Ohio (James), New York (Peck).

9. FOMES SCUTELLATUS (Schw.) Cooke

Polyporus scutellatus Schw. Trans. Am. Phil. Soc. **4**: 157. 1832.

Fomes scutellatus Cooke, Grevillea, **14**: 19. 1885.

This minute species was described by Schweinitz from material collected on *Syringa* in Pennsylvania. It has since been found on alder, witch hazel, sweet gum and other deciduous shrubs and trees. Some of the collections examined are as follows: Pennsylvania (Everhart), Florida (Calkins), Maine (Harvey, Blake), Canada (Macoun), Delaware (Commons), Ohio (James), Alabama (Mell).

10. **Fomes Laricis** (Jacq.)

Boletus Laricis Jacq. Miscel. **1**: 164–203. *pl. 20–21.* 1778. Bull. Herb. France, *pl. 296.* 1786.

B. officinalis Villars, Delph. 1041. 1786.

B. purgans Pers. Syn. 531. 1801.

Polyporus officinalis Fr. Syst. **1**: 365. 1821.

This fungus has been known from ancient times on account of its medicinal properties and is still collected in considerable quantities in the larch forests of Europe and Asia for use in medicine. Single specimens are sometimes found weighing as much as fifteen pounds in the dry state. Many of the older botanists mention this plant. Bauhin (Pinax, 375. 1623) gives a good general description of it under the name "*Agaricum, sive fungus laricis.*" Micheli figures it (Gen. *pl. 61. f. 1.* 1729). Even Dioscorides knew its value. According to Miss Southworth, the substance of the fungus consists mostly of resin-granules about knots of mycelium, containing at times one or more curiously shaped bodies resembling branching bast cells, which grow out from the mycelium. These resin-granules contain the medicinal properties.

The European host of this fungus is the living larch. In America, it has been found also on pine and spruce. Specimens found in Michigan in 1886 on living white pine were used by Calkins and others instead of quinine. MacDougal collected a very handsome specimen on dead spruce in Montana in July, 1901. Macoun also found it on spruce in British Columbia in April, 1889. A recent note in Science from Professor Bessey refers to specimens received by him from Montana and the Yellowstone Park, collected on undetermined species of conifers. Calkins' report of this species in America a dozen or more years ago evidently escaped Professor Bessey's attention.

11. FOMES POPULINUS (Schum.) Cooke

Boletus populinus Schum. Enum. Pl. Saell. **2**: 384. 1803.

Poria obducens Pers. Myc. Eur. **2**: 104. 1825.

Polyporus connatus Weinm. Fl. Ross. 332. 1836. En. Stirp. Petrop. 208. 1837.

Polyporus connatus Fr. Epicr. 472. 1836–1838. Icon. *pl. 185. f. 2.*

Fomes connatus Gill. Champ. France, **1**: 684. 1878.

Fomes populinus Cooke, Grevillea, **14**: 20. 1885.

Finland (Karsten), Bavaria (de Thümen), Germany (Sydow), England (Massee), Sweden (Murrill), Canada (Dearness, Macoun),

Georgia (Ellis), Ohio (James, Morgan), Delaware (Commons), New York (Earle, Underwood), Massachusetts (Underwood), Pennsylvania (Herbst), Florida (Martin), New Jersey (Ellis), Missouri (Glatfelter).

The favorite host of this species is the maple, though it is also found on poplar, linden and a few other deciduous trees. Living Norway maples in Sweden were found to be seriously injured by its attacks, and I have noticed it on this and other species of maple used as shade-trees in American cities.

12. **Fomes Meliae** (Underw.)

Polyporus Meliae Underw. Bull. Torrey Club, **24**: 85. 1897.

Described from specimens collected by Underwood on branches of *Melia Azederach* in 1895. It also occurs on *Gleditsia* and *Fraxinus*, as is indicated by the recent Alabama collections of Earle and Baker.

13. **Fomes rubritinctus** sp. nov.

A large perennial plant of many layers, the upper partly dead and discolored, the lower smooth, light-colored and anoderm with large pores, which become dark red when bruised. Pileus corky to woody, dimidiate, convex, 4–12 × 5–15 × 3–10 cm.; surface anoderm, smooth, velvety to the touch, white or pallid, becoming dark brown and roughened with age; margin obtuse, sterile, concolorous: context corky, becoming woody, pallid, 1.5 cm. thick: tubes unevenly stratified, the layers separated by unusually thick cushions of context, 0.5–1.0 cm. long each season, 2 to a mm., isabelline within, becoming umbrinous in the older layers; mouths subcircular or polygonal, edges thin, isabelline, becoming dark red when bruised: spores ovoid to globose, 5–7 μ long, smooth, hyaline, wall of medium thickness, hyphae hyaline.

Collected by C. L. Smith in Nicaragua and distributed as no. 138 of his Central American Fungi.

SPECIES INQUIRENDAE

Fomes geotropus Cooke, Grevillea, **13**: 119. 1884 (*Polyporus geotropus* Cooke, Grevillea, **13**: 32. 1884). This species is allied to *Fomes ulmarius* Fr. It was described from collections in Demerara, but seems to range northward to Mexico, Florida and Alabama. Other doubtful or unknown species are: *Fomes perpusillus* (Pers.) Cooke, *F. extensus* (Lév.) Cooke, *F. aegerita* (Fr.) Cooke, *F. microporus* (Sw.) Cooke, and *F. albogriseus* Peck.

NEW YORK CITY.

Four new Species of Grasses from Washington

By C. V. Piper

Elymus curvatus

Culms erect, often geniculate at base, about one meter high, glabrous; nodes glabrous: culm-leaves four or five; sheaths glabrous, the upper exceeding the internodes, the lower ones usually shorter; ligule none; blades flat, 15–20 cm. long, 5–7 mm. wide, scabrous on both sides, especially beneath: spikes stout, erect, barely exserted from the uppermost sheaths, 10–12 cm. long, green: empty glumes lanceolate, rigid, thick, 3–5-nerved, scabrous on the margins and on the nerves above the middle, acuminate, 13–17 mm. long, often curved or twisted, shining: spikelets 2–4-flowered, mostly 3-flowered: flowering glumes pale, 3–5-nerved near the apex, sparsely hispidulous above the middle, oblong-lanceolate, acuminate, 8–10 mm. long, tipped with a straight awn 1–2 mm. long: palea hardly equalling the flowering glume, scabrous-ciliate: internodes of the rachis 4–7 mm. long, scabrous on the nerves, apex and margins.

A peculiar species not closely related to any other known to me. Collected by Mr. Frank O. Kreager, no. 375, in Box Cañon, Pend Oreille River, Stevens County, Washington, Aug. 2, 1902.

Sitanion velutinum

Culms tufted, erect, rigid, densely puberulent, 30–40 cm. high: innovations few, short: sheaths exceeding the internodes, rather closely fitting, open in the throat, densely and minutely velutinous; blades flat, lanceolate, gradually attentuate from base to apex, acute, erect or divergent, densely puberulent on both sides; culm-leaves three or four, the lower 6–10 cm., the upper 2–4 cm. long; ligule obsolete: spikes well exserted, stiffly erect, 4–8 cm. long without the awns: spikelets two at each node or rarely one, the lower 1–2-flowered and frequently sterile, the upper 2–4-flowered, one to three of the florets fertile: empty glumes subulate, puberulent, 5–7 mm. long, mostly entire, but one or two often cleft and bearing a short lateral awn or rarely cleft to the base, each tipped with a scabrous spreading awn 3–5.5 cm. long: flowering glumes lanceolate, puberulent, 9–11 mm. long, 3-nerved above, trifid, the lateral lobes 1 mm. long, the stout awns 3–5.5 cm. long: palea as long as the flowering glume, acute, scabrous on the nerves:

internodes of the rachis linear-clavate, 4–6 mm. long, puberulent near the apex, minutely scabrous on the margin above.

Steptoe, Whitman County, Washington, collected by G. R. Vasey, July 5, 1901.

Sitanion basalticola

Densely tufted, the whole plant smooth and glaucous: culms 10–20 cm. high, barely exceeding the leaves of the numerous innovations: sheaths exceeding the internodes; ligule obsolete; blades involute, erect or recurved, 3–10 cm. long, 2 mm. wide, smooth beneath, minutely scabrous on the nerves above: spikes 3–5 cm. long, without the awns, erect, barely exserted from the upper sheaths: spikelets two at each joint, the lower with one sterile floret, the upper with three florets, two of them usually fertile: empty glumes or divisions mostly six or eight, subulate, entire, scabrous, about 6 mm. long, each tipped with a spreading awn, 2–3.5 cm. long: flowering glume 8–10 mm. long, glabrous and glaucous, excepting the three nerves at apex, these scabrous, the lateral ones prolonged into bristles 1 mm. long, the middle one into a stout scabrous divergent awn, 3–3.5 cm. long: palea as long as the flowering glume, minutely scabrous on the margin above the middle, emarginate at apex: internodes of the rachis flattened, linear or linear-spatulate, scabrous on the margins above.

In basaltic soil, Coulee City, Washington, collected by the writer, June 1, 1902, no 3924.

Sitanion rubescens

Culms tufted, erect, somewhat geniculate at the lower nodes, glabrous, about 60 cm. high; nodes brown: sheaths mostly shorter than the internodes, rather closely fitting, glabrous; ligules obsolete or nearly so; blades flat, green, linear, attenuate to the acute apex, 5–10 cm. long, 3–5 mm. broad, glabrous above, scabrous on the nerves beneath, where the latter are more prominent than above: spikes long-exserted, straight or flexuous, erect, 8–13 cm. long: spikelets mostly two, rarely three, at each joint, the lower or lateral ones 1–2-flowered, mostly sterile, the upper or middle ones 2–3-flowered, the lower one or two florets fertile: empty glumes lanceolate, frequently oblique, 2–3-nerved, scabrous on the nerves, 6–7 mm. long, each bearing a stout divergent scabrous awn, 1–2 cm. long, or the glumes very rarely bifid and bearing in addition a short lateral awn: flowering glumes lanceolate, 10–12 mm. long, smooth and shining below, 3–5-nerved and scabrous above, each bearing a stout straight or flexuous scabrid purplish awn, 1.5–5 cm. long: palea as long as the flowering glume,

truncate, scabrous on the nerves above: internodes of the rachis spatulate, flattened, scabrous on the margins, 6–8 mm. long.

Dry rocky places, 2300 m. altitude, Mount Rainier, Washington, collected by the writer, in August, 1895, no. 1954. This species is nearest allied to *S. lanceolatum* J. G. Smith.

PULLMAN, WASHINGTON.

New Plants from Colorado

By George E. Osterhout

Cryptanthe gracilis

Annual: stem branched, erect, slender, 1–1.5 dm. high, sparsely hispid; leafy to the inflorescence, but the leaves rather few and remote, narrowly oblanceolate and rounded at the apex, about 1 cm. long, sessile, hispid on both surfaces but not densely so: inflorescence pedunculate, scorpioid, from the ends of the branches: flowers small: corolla white: fruiting calices becoming rather remote; lobes slender, having no noticeable midrib, densely hispid with whitish hairs, attaining a length of 3 mm.: nutlet solitary, narrowly ovate, acuminate, smooth, triangular in cross section, but not sharply angled, 2 mm. long, a little longer than the large gynobase to which it is attached for about half its length.

Collected only at Glenwood Springs, Garfield Co., Colo., June 6, 1902, no. 2589.

Aulospermum planosum

Perennial from a long fleshy root: stem naked with scarious sheaths at base, 5–7 cm. high, crowned by the leaves and peduncles which stand at right angles to the stem, making the top somewhat flat: leaves glaucus, ovate in outline, 7–8 cm. long, on rather long peduncles, bipinnatifid, the divisions mostly entire, but some of them lobed: peduncles longer than the leaves: involucre none: bracts of the involucels few and linear: umbel of 6 or more rays, 2–3 cm. long: pedicels about 2 mm. long: flowers purple: fruit oblong, 6 mm. long, broadly winged, oil tubes 5–6 in the intervals, 10–12 on the commissure.

Collected along the Eagle River at Minturn, Eagle Co., Colo., June 5, 1902, no. 2572.

Touterea multicaulis

Perennial, many-stemmed and much branched: stems whitish, smooth and shining, but slightly hispid at summit, 2–3 dm. high: lower leaves including the short petiole about 0.5 cm. long, pinnatifid, the divisions remote and entire; upper leaves narrowly linear, entire and sessile: flowers numerous from the ends of the branches, opening at sundown or a little before, and closing again in about half an hour: peduncles short: calyx-lobes deltoid, acu-

minate, almost 1 cm. long: petals 5, golden yellow, 1.75 cm. long including the short claw: several of the outer filaments petaloid: capsule appressed-hispid, 1 cm. long: seeds round, smooth, 2.5 mm. in diameter, margined but not winged.

Type specimens collected at Wolcott, Eagle Co., Colo., July 11, 1902, no. 2663. It is found from the Eagle River at Wolcott northward to the Grand River.

Lepidium divergens

Seemingly a biennial, 1.5–2 dm. high, much branched from the base, the branches divergent and procumbent, attaining a length almost equal to the central upright stem: stem, branches and pedicels minutely pubescent: lower leaves spatulate, 2–5 cm. long, rounded or acute and few-toothed above, tapering to a narrowly winged petiole, diminishing upwards and becoming entire: stem and branches becoming fruit-bearing for two thirds of their length or more: pedicels horizontally spreading, about 3 mm. long: flowers small: petals none: sepals soon deciduous: stigma sessile: capsule emarginate, elliptical, 3 mm. long by 2.5 mm. wide: cotyledons incumbent.

Type specimens collected at Tennessee Pass, Lake Co., Colo., July 10, 1902, no. 2642. Collected also at Yampa and Steamboat Springs in Routt Co., Colo.

NEW WINDSOR, COLO.

New Species of Oreocarya

By Alice Eastwood

In 1892 and 1895 the author collected several species of *Oreocarya* in Colorado and Utah which differed from each other and did not agree with any of the then described species. These were laid aside on account of more pressing work. Some of these have since been described by Dr. E. L. Greene and Professor Aven Nelson; but there still remain several which apparently have not come under the observation of these botanists, while others are to be found in the herbarium of the California Academy of Sciences which, in the opinion of the author, have been incorrectly assigned to species from which they differ sufficiently to be considered distinct.

Duplicates of types of many of the species are in the Academy's herbarium and I have besides, through the kindness of Mr. Carl F. Baker, had the opportunity of examining others which we did not possess.

Oreocarya disticha

Stems several from a woody perennial root, erect, slender, about 3 dm. high, with few erect branches, canescent with fine short closely appressed pubescence and few longer appressed bristly hairs: radical leaves wanting but the remains of the broad sheathing petioles indicating a cluster; cauline leaves somewhat scattered, oblanceolate, tapering to margined petioles which are dilated and clasping at base, upper surface appressed-pubescent, lower appressed-hirsute and pustulate, acute, entire, of falcate outline when the edges are folded together, 2–4 cm. long: panicle becoming 8 cm. or more long, pedunculate, branching into a few slender spikes, with the flowers close and distichous on pedicels less than half as long as the sepals; bracts linear, but little surpassing the pedicels, the upper ones very small: divisions of the calyx involute, keeled, ovate-lanceolate, 4 mm. long, conniving around the fruit but with the obtuse tips spreading, pubescence like the stem: corolla white; limb with the divisions obovate-oblong, entire, obtuse, extending almost to the throat, a little more than 2 mm. long and almost as wide, about 5 mm. shorter than the tube; tube constricted at base and throat with the crests in

the throat half as long as the anthers, those at base forming a moniliform ring that closes around the style above the ovary: stamens inserted in the throat, the upper part of the anthers alternating with the crests: fruit with but one nutlet maturing, this sharply keeled on the ventral side, rounded and arched on the dorsal, acutely margined, depressed, mottled dark and light brown, glossy, slightly roughened with a few scattered papillae.

This is to be included in the group formerly under *Krynitzkia Jamesii* Gray. It was reported with that name (no. 90) in my Report on a Collection of Plants from San Juan County, Southeastern Utah, Proc. Cal. Acad. Sci., II. **6**: 311. It was collected by the writer on the mesa above the San Juan River, Utah, on what was known as Barton's Range, July 13, 1895. It differs from *O. suffruticosa* (Torr.) Greene, in habit, pubescence, flowers and seeds. In habit of growth it more closely resembles *O. multicaulis* (Torr.) Greene, but differs in the size of the flowers, the number and appearance of the nutlets.

Oreocarya Lemmoni

Stems several from a branched caudex, about 10–15 cm. high, rather stout and leafy, floriferous throughout, densely yellowish or white tomentose and hairy with long fine white soft hairs, neither striate nor ribbed: leaves linear-oblanceolate, obtuse, with no distinction of petiole and blade; the lowest 9 cm. long, diminishing to the bracts, 1 cm. long, 2–5 mm. wide, tomentose and but slightly hairy: inflorescence with axillary clusters capitate on peduncles 5–10 mm. long; bractlets long, surpassing the sessile or short-pedicelled flowers; terminal spikelets aggregated into capitate clusters (in flower): divisions of calyx ovate-acuminate, almost as long as the corolla, 4 mm., densely tomentose and sparingly hairy: corolla white; tube campanulate, broadening from a base 1 mm. in diameter to the throat more than 2 mm. across, 2.5 mm. long; lobes orbicular, extending almost to the throat, 2 mm. wide; crests in throat conspicuous, 1 mm. wide at base, bilobed at apex, fleshy; crests at base small, forming a moniliform ring less than 1 mm. from the base: stamens with oblong anthers, attached below the middle of the tube by very short broad filaments, the apex reaching the base of the crests in the throat: nutlets immature but apparently smooth and depressed like *O. suffruticosa* Greene.

This is well distinguished from all other members of the group and from all other species of the genus by the peculiar shape of

the corolla. All others that are known are distinctly salverform while this approaches the rotate form. It was collected by J. G. Lemmon, in whose honor it is a pleasure to name it, in Arizona, without definite locality, 1884. The type is in the Herbarium of the California Academy of Sciences.

Oreocarya celosioides

Stems stout, apparently simple from a leafy caudex which is clothed with the broad imbricated petioles of former leaves, 8 mm. in diameter, more than 4 dm. high, floriferous from above the middle, leafy, striate, setose-hispid with stiff tawny or white bristles and pubescent beneath the bristles with dense intricately appressed pubescence; radical leaves mostly wanting, the persistent bases of the petioles remaining, these about 6 mm. broad, densely clothed with fine white appressed hairs and ciliate with spreading white bristles; the one or two small persistent leaves spatulate with petioles 2–3 times longer than the blades, together 3 cm. long, pubescence as on the stem, except that the bristles are pustulate at base; cauline leaves linear-lanceolate, 2–4 cm. long, 3–4 mm. wide, sessile, hispid with numerous very stiff bristles: inflorescence of thick, densely clustered, unilateral spikes, elongating upwards; bractlets conspicuous, linear, shorter than the calyx: calyx about equalling the tube of the corolla, densely setose with yellowish bristles; divisions linear-lanceolate, 5 mm. long in flower, becoming 15 mm. in fruit, conniving over the nutlets but with the foliaceous tips free: corolla white with orbicular divisions extending to 1 mm. of the throat, 4 mm. long and of equal width; tube 5 mm. long, with the crests in the throat small, obtuse, less than 0.5 mm.; scales at base forming a moniliform ring above the ovary, less than 1 mm. from the base: anthers oblong, 1.3 mm. long, not quite reaching the crests; filaments short and broad, inserted about the middle of the tube: nutlets erect, acute, slightly cordate at base, keeled on the dorsal side and with the narrowly winged margins elevated so that there is a shallow concavity between the ridge and the continuous margin, 5.5 mm. long, 3 mm. wide, rugose with transverse ridges and fine papillae between; scar shallow and narrow, not extending to the apex nor forked at base, nor extending to the very base; gynobase subulate, 5 mm. long, attached for almost its entire length.

This approaches *O. setosissima* (Gray) Greene. It differs in the denser inflorescence, resembling somewhat that of *Celosia cristata* L., its larger flowers and different nutlets. It was distributed as *Eritrichium glomeratum* DC. by Thos. J. Howell, from

the banks of the Columbia River, eastern Washington, July, 1881.

Oreocarya elata

Stems one to several from a woody tap-root, 3–4 dm. high, virgate, ribbed, floriferous from near the base with sessile or peduncled clusters which form heads of few to several flowers in the somewhat distant leaf-axils, later becoming spikes; summit of the stem branched, forming a panicle of unilateral bracteate spikes which are at first capitate but later lengthen, the lower flowers becoming distant more than their own length: pubescence of lower part of stem and leaves snowy white, consisting of densely appressed and interlaced fine hairs with some scattered appressed bristles mostly pustulate at base; pubescence of the upper leaves and inflorescence tawny and more spreading: radical leaves densely clustered on the caudex, spatulate, entire or crenate, acute or obtuse, with the margined petioles as long as the blade, together 2–3 cm., strongly ribbed; cauline leaves distant from each other 1–3 cm., lanceolate, together with the broad margined clasping petioles 2–4 cm. long, 5 mm. wide: divisions of the calyx ovate with strong midvein, 4 mm. long, 2 mm. wide at base, densely hispid, surpassing the tube of the corolla, enlarging in fruit, conniving over the nutlets but with the tips spreading: corolla white; tube 3.5 mm. longer than the orbicular lobes which do not extend to the throat; crests slightly emarginate, fleshy, arching over the elliptical anthers; basal scales crescent-shaped, forming a ring 1 mm. from the base: anthers 1.5 mm. long, 1 mm. wide, on short broad concealed filaments: nutlets erect, ovate, with the lateral edges acutely margined but not winged, obtuse, tuberculate with glossy white tubercles which are separate or confluent in irregularly transverse ridges, especially along the middle of the dorsal surface: gynobase subulate; scar forked at base and extending almost to the apex.

This is nearest to *O. setosissima* (Gray) Greene from which it differs in all its parts. It was collected by the author near Grand Junction, Colorado, on the road to the coal mines, growing on the bare clay hills characteristic of the region, flowering May 15, fruiting June 28, 1892.

Oreocarya aperta

Caudex branched from a woody root, with leaves densely clustered at base and the dilated petioles imbricated: stems several, rather slender, 1–2 dm. high, branching from near the base with many spreading simple or 2-forked spikes, those of all the stems aggregated into a closely branched thyrse: pubescence gray, setose-hispid, the spreading white bristles pustulate at base, 2–3 mm.

long, the surface under the bristles clothed with fine white densely and intricately appressed hairs: radical leaves spatulate to oblanceolate, together with the margined petioles 3 cm. long, 8 mm. wide, the midrib forming a ridge on the lower surface; cauline leaves oblanceolate, about as long as the radical leaves but narrower: spikes peduncled, longer than the subtending leaves, distichous or unilateral; bractlets linear, longer than the internodes, shorter than the mature calyx; pedicels very short, about 0.5 mm. long: divisions of the calyx subulate-acuminate, equalling the tube of the corolla in flower, elongating from 3–10 mm., strongly ribbed, densely setose, not conniving over the nutlets but spreading open and becoming campanulate, readily disarticulating from the peduncles when the seed is ripe, leaving an umbilicate scar at the base of each spreading bractlet: corolla white; tube equal to the limb, together 6 mm. long; divisions not extending to the throat, obovate with the apex obcordate or obtuse, 2.5 mm. broad, margin obscurely sinuate; crests conspicuous, 1-nerved, truncate, 0.5 mm. long and as broad; crests at base less than 1 mm. from the bottom, forming a moniliform ring of 10 nipple-like projections around and above the ovary: anthers oblong, 1.25 mm. long, concealing the short broad filaments and extending to the base of the crests: nutlets erect, 2.5 mm. long, ovate, obtuse, the dorsal ridge prominent, acutely margined all around; scar sulcate, extending almost to the apex, not forked at base, rough with glossy white papillae which are confluent into small papillae, becoming somewhat star-shaped in outline, the smaller papillae intervening: gynobase linear-subulate.

This is near *O. thyrsiflora* Greene, but is entirely distinct. It was collected by the author at Grand Junction, Colorado, June 27, 1892.

Oreocarya Wetherillii

Biennial from a slender tap-root, the caudex densely clothed with the petioles of former leaves, branched from the base with one stout stem and one or more low slender ones, 1–3 dm. high: leaves and stem white with densely appressed interlaced fine hairs and spreading bristles pustulate at base: radical leaves spatulate, obtuse or acute, with blades as long as the broad margined petioles, which are dilated and imbricated at base, 1–3 cm. long, 5–10 mm. broad: glomerule extending from the base, consisting of numerous unilateral or distichous spikes with oblong sessile bracts diminishing upwards; bractlets linear-lanceolate, equalling or surpassing the calyx: calyx of 5 narrow, linear divisions, 5 mm. long, densely hispid with white bristles, which are tawny in bud, in fruit conniving over the nutlets but with spreading tips, becom-

ing 1 cm. long: corolla white with orbicular lobes not extending to the throat, nor so long as the tube, together equalling 6 mm.; the tube surpassing the calyx in flower; crests hispid, rounded, base of tube without scales or crests: anthers linear-oblong, inserted below the crests on short subulate filaments which are concealed by the anthers: nutlets erect, ovate-oblong, 2 mm. broad, 3–5 mm. long, obtuse, acutely margined on the lateral angles, inserted almost the entire length, rarely all maturing; scar scarcely forked at base, when ripe the surface brown, covered with glossy white, irregular, minute, often confluent tubercles: gynobase elongated-subulate.

This showy species is related to *O. thyrsiflora* Greene but differs in the naked base of the corolla-tube, the hispid crests in the throat, and in the longer tube of the corolla. It was collected by the author in flower and fruit, May 25, 1892, in Court House Wash, near Moab, southeastern Utah. It is named in honor of Mr. Alfred Wetherill who was my guide and companion on the trip when it was discovered.

Oreocarya nana

Stems low, caespitose, 5–10 cm. high, 3–several from a slender tap-root, the simple or branched caudex densely covered with the petioles of former leaves, hispid throughout with spreading white or yellowish bristles which are frequently pustulate at base, striate, floriferous almost from the base: radical leaves crowded on the caudex, white with closely appressed hairs mixed with coarser bristles, oblanceolate, petiolate, acute, 1–2 cm. long, 2–5 mm. wide; cauline leaves few, similar to the radical but shorter, the appressed hairs tawny, the bristles white and more spreading: inflorescence spicate-glomerate, 4 cm. long, 1–2 cm. wide: flowers 1–3 in the axils of the linear bracts, with pedicels shorter than the bracts, half as long as the calyx: divisions of calyx linear-subulate, longer than the corolla-tube, 4.5 mm. long, enlarging in fruit and conniving over the nutlets, outer surface densely clothed with spreading yellow bristles, inner with the bristles appressed: corolla white, the tube shorter than the limb; divisions broadly oval to orbicular, not extending to the throat, 3 mm. long, equalling the tube; crests in the throat prominent, rounded, half as large as the anthers; crests at base nipple-like, in pairs, 1 mm. from the bottom: anthers on scarcely perceptible subulate filaments, oblong, 1 mm. long, inserted below the crests in the throat: nutlets 1–2 maturing, erect, ovate, obtuse, keeled on the dorsal side and rough with sharp transverse interrupted muriculations, having fine

papillae intervening; ventral surface with coarser papillae; scar open and broad like a furrow, forked at base, reaching within 0.5 mm. of the apex: gynobase elongated-subulate.

This is perhaps nearest to *O. caespitosa* A. Nelson from which it differs in fruit and floral organs as well as habit and pubescence. It was collected by the author near Grand Junction, Colorado, on the mesa above the Gunnison River, May 17, 1892.

Oreocarya cristata

Caudex with many branches from a slender woody tap-root, apparently perennial; stems slender, about 2 dm. high, ribbed, not floriferous at base, pubescent with appressed tangled hairs and fine spreading white bristles which are 2 mm. long: leaves oblanceolate-spatulate, with broad petioles dilated at base, the lower ones twice as long as the blades, the upper about equalling them, together 1.5–5 cm. long; blades 6 mm. broad; petioles 4 mm. broad at base; pubescence on younger leaves tawny, that on older ones cinereous with appressed hairs and bristles, the latter pustulate at base; pubescence of inflorescence gray or tawny: inflorescence a compound spike or glomerule, little more than half as long as the stem; peduncles 2–4 mm. long; pedicels about 1 mm. long: spikelets 2–4-flowered: calyx of five lanceolate very bristly divisions 6 mm. long, not enlarging much in fruit, shorter than the tube of the corolla, with pubescence gray or tawny: corolla with broad orbicular divisions, not extending to the throat, 4 mm. broad; tube almost 1 cm. long; crests in throat conspicuous, oblong, 1 mm. long, without scales or crests at base: anthers oblong, more than 2 mm. long, almost sessile, the apex 1 mm. from the base of the crests: nutlets globose, incurved, ovate, acutely margined to the scar, rough with transverse ridges and minute papillae intervening; scar broad and open, with open, forking base: gynobase mitriform.

This is peculiar in the broad limb of the corolla with orbicular lobes, the prominent crests in the throat of the corolla-tube, and the peculiar nutlets of which one was generally abortive. This was collected by the author at Grand Junction, May 17, 1892.

Oreocarya tenuis

Caudex densely clothed with dry imbricated petioles, much branched from a woody tap-root having a dark brown epidermis: stems many, slender, erect, 1–2 dm. high, ribbed, floriferous from near the base with few scattered flowers or clusters, above becom-

ing a panicle of pedunculate spikes, grayish throughout with a rough pubescence of closely appressed hairs and some scattered white bristles which are pustulate at base: leaves spatulate-oblanceolate, tapering to broad petioles which exceed the blade and are dilated and clasping at base, together with the blade 1–3 cm. long, 2–5 mm. broad, acute, entire but bristly ciliate, appressed-hispid on the upper surface, lower surface with bristles as on the stem, the midrib forming a ridge through the center: internodes 1–2 cm. long: spikes peduncled, few-flowered (2–5); pedicels 1–3 mm. long, with or without bractlets, which when present surpass the pedicels: calyx shorter than or equalling the tube of the corolla, with linear-acuminate divisions 6 mm. long, hispid with spreading bristles, the margins whitened by densely appressed white hairs: corolla white; tube 5 mm. long, exceeding the border by 1 mm.; divisions oblong, 3 mm. long, 2 mm. wide, obtuse, not extending to the throat; crests in the throat bisected by a central ridge, short and broad: anthers linear-oblong, 1.5 mm. long, inserted about the middle on short broad filaments, the apex about on a level with the top of the crests; no scales or crests at base of tube: nutlets ovate, obtuse, 3 mm. long, 2 mm. wide, acutely margined except below the scar; dorsal surface keeled, corrugated-rugose with the epidermis pale gray and lucid; scar broadest at the middle and with broad bifurcation at base: gynobase mitriform, 4-angled.

This peculiar species is distinguished from all others by the more slender stems and more contracted inflorescence. Its long corolla-tube marks it as distinct from any of the group formerly included under *O. glomerata*. It was collected by the author near Moab, in Court House Wash, southeastern Utah, May 25, 1892. It grew in red sandy soil.

Oreocarya Shockleyi

Stems several from a tufted branching caudex which is densely clothed with dry imbricated petioles of former leaves, 1–2 dm. high, leafy, striate, not more than 2 mm. in diameter, floriferous from the middle, cinereous with downwardly appressed pubescence and spreading fine white silky bristles which are 1–2 mm. long: leaves on caudex oblanceolate, tapering to a broad petiole which is dilated and ciliate at base, strongly ribbed, together with the blade 3–6 cm. long, 3–7 mm. wide, cinereous with fine, white appressed pubescence and fine scattered bristles with papillae at base which dot the surface; cauline leaves linear-oblong or narrowly oblanceolate, sessile or with petioles more than half as broad as the blades: spikes consisting of short-peduncled spikelets or

heads, containing from two to five sessile flowers, the lower clusters somewhat distant, the upper becoming almost capitate: bracts, the diminished upper leaves; bractlets linear, about equalling the divisions of the calyx: calyx 7 mm. long, shorter than the tube of the corolla, with lanceolate-acuminate divisions 6 mm. long, ribbed, with the pubescence yellowish, appressed and bristly, densely so on the outer surface and the foliaceous tips of the inner, the lower part conniving over the nutlets: corolla white, the tube twice as long as the limb, 9 mm.; divisions orbicular, 4 mm. long and wide, crenate-sinuate; crests truncate, slightly emarginate, minutely papillate, 1 mm. long; no crests or scales at base of corolla-tube: anthers linear-oblong, almost 2 mm. long; on short broad filaments, inserted below the middle of the anthers, the apex reaching to 1 mm. below the crests: nutlets ovate, 4 mm. long, dorsal side arched and keeled; surface rough with pointed muriculations like microscopic mountain peaks and with fine vermiculate elevated lines intervening, margined except at base, ventral surface with similar sculpture, the scar protuberant, extending from near the summit, broadening to the deep fork which is about 2 mm. across: gynobase conical, about 3 mm. high.

This well-marked species was collected by W. H. Shockley, in whose honor it is named. It was collected in gulches on Miller Mountain, Esmeralda County, Nevada, at an elevation of 7500 ft. It is No. 244 of Mr. Shockley's collection, distributed as *Krynitzkia fulvocanescens* Gray.

CALIFORNIA ACADEMY OF SCIENCES.

Studies on the Rocky Mountain Flora.—X

By Per Axel Rydberg

Corispermum marginale sp. nov.

Annual: stem glabrous, much branched, 2–5 dm. high: leaves narrowly linear, 2–5 cm. long, 1.5–2 mm. wide: spike 3–8 cm. long, rather dense; bracts usually overlapping each other, the lower lanceolate, about 1 cm. long, the upper ovate, 5 mm. long; all more or less acuminate, with a strong midrib and conspicuous scarious margins, slightly pubescent when young or glabrate: fruit about 4 mm. long and 2.5 mm. wide, with a broad wing margin.

This is perhaps most nearly related to *C. hyssopifolium* of the salt marshes of the coast regions, but is taller, more slender, with less fleshy leaves, smaller fruit and more conspicuously scarious-margined bracts. From *C. nitidum* it differs in the broader bracts, denser spikes and larger fruit. It grows in similar localities, viz., in sandy soil, in draws and ravines.

New Mexico: Albuquerque, 1884, *C. L. Herrick* (type in herb. N. Y. Bot. Garden).

Colorado: Huerfano Valley, near Gardner, 1900, *F. K. Vreeland, 657;* Rocky Ford, 1893, *Crandall;* Denver, 1887, *S. M. Tracy.*

Chenopodium Watsoni A. Nelson, Bot. Gaz. **34**: 362. 1902

Chenopodium olidum S. Wats. Proc. Am. Acad. **9**: 95. 1874, mainly. Not Curt.

Annual, rather stout, sparingly farinose, 2–6 dm. high: stem branched, striate and sometimes tinged with red: leaves rather thick; petioles 2–10 mm. long; blades 1–2 cm. long, oval, ovate or oblong, obtuse and occasionally cuspidate-mucronate, dark green and sparingly mealy: inflorescence narrow, dense: flowers 1 mm. in diameter: seed 1.25–1.5 mm. in diameter: pericarp mealy and closely adherent.

Watson's name being preoccupied, I apply Nelson's substitute to this species as it is Watson's *C. olidum* as to the description and most specimens cited. Several specimens given by him belong, however, to the next species, which has been confused with

it. Mr. Powell sent some seeds to Elihu Hall. A specimen raised from these seeds and preserved in the herbarium of Columbia University I take as typical *C. Watsoni.*

Chenopodium Wolfii sp. nov.

Chenopodium olidum S. Wats. Proc. Am. Acad. **9**: 95. 1874, partly.

Annual, sparingly mealy: stem erect, 3–4 dm. high, often branched, striate: leaves moderately thick, dark green, only slightly mealy; petioles about 1 cm. long; blades 1–3 cm long, oblong to ovate-lanceolate, entire or rarely slightly hastately toothed, obtuse: inflorescence dense, narrow: flowers small: seeds less than 1 mm., usually .75 mm. in diameter: pericarp thin and easily separated from the seed.

Closely resembling the preceding in habit, but is easily distinguished by the smaller flowers and seed and the separating pericarp. These characters place it nearest to *C. oblongifolium* Nutt., from which it differs in the less mealiness and the smaller seeds.

COLORADO: Twin Lakes, 1773, *John Wolf, 253*, apparently also *258* and *263*.

WYOMING: Wamsutter, 1897, *Aven Nelson, 3671*.

Endolepis ovata sp. nov.

Low, annual, usually less than 1 dm. high: stem branched, straw-colored or pinkish, almost glabrous: leaves subsessile, usually less than 1 cm. long, ovate or lance-ovate, 3-nerved at the base, sparingly mealy: pistillate flowers solitary in the axils of the middle leaves: staminate flowers in small clusters in the axils of the upper leaves or at the end of the branches, otherwise as in *E. Suckleyana* Torr.

In my opinion Dr. Torrey was correct in separating *Endolepis* from *Atriplex.* It is interesting to find a second species of the former genus, which hitherto has been known as monotypic. The original *Endolepis* has narrowly lanceolate leaves, which are thinner and without lateral ribs.

WYOMING: Buffalo, 1900, *Frank Tweedy, 3290* (type in herb. N. Y. Bot. Garden); Wallace Creek, 1898, *Elias Nelson, 4999*; Rock Creek Station, 1881, *L. F. Ward.*

MONTANA: Glendive, 1892, *J. H. Sandberg.*

Cleomella cornuta sp. nov.

Annual: stem straw-colored, 2–3 dm. high, branched below with ascending branches, glabrous throughout: leaves ternate; petioles 1–1.5 cm. long; leaflets 1–2 cm. long, oblong or oblong-oblanceolate, obtuse, mucronate: inflorescence short: pedicels very slender, almost 1 cm. long: sepals yellowish, ovate, cuspidate, less than 1 mm. long: petals light yellow, narrowly oval, clawless, about 3 mm. long: filaments about twice as long: fruit broadly rhombic, broader than long, about 3 mm. long and 4 mm. broad; the corners often produced into short processes: stipe 6–8 mm. long; beak over 1 mm.: seeds about 2.5 mm. long, 1.75 mm. wide, smooth and unmarked.

This is related to *C. oocarpa* and *C. plocasperma*, but has broader leaflets. From the former it also differs in the strongly rhombic pod and from the latter in the broader and unmarked seeds. The type grew at an altitude of 1350 m.

UTAH: Cainsville, 1894, *Marcus E. Jones, 5656* (type in U. S. Nat. Herb.).

Cerastium Earlei sp. nov.

Perennial with a slender branched and stoloniferous rootstock: stems weak, ascending, 2–3 dm. high, viscid-puberulent, branched: leaves oblong or oblanceolate, obtuse, viscid-puberulent, 1.5–3 cm. long, 3–8 mm. wide: inflorescence open; bracts ovate or ovate-lanceolate, not scarious; pedicels 2–2.5 cm. long: sepals lanceolate, acute, sparingly pubescent, scarious on the margins, about 5 mm. long: petals about 1 cm. long or more, fully twice as long as the sepals, not very deeply cleft.

The type number was determined by M. E. Jones as *Cerastium alpinum* near var. *glabratum*, and the other two numbers of the Baker, Earle and Tracy collection are labeled *Cerastium* ———, and *Cerastium arvense oblongifolium*, respectively. The six sheets (two of each number) in the N. Y. Botanical Garden herbarium (except one of number *621*, which represents a luxuriant state) are so alike that it is impossible to refer them to different species. In the size of the flowers, form of the leaves and general habit, the species resembles most *C. alpinum*, but the pubescence is different: in *C. alpinum* long-villous and less viscid, in *C. Earlei* very short and very viscid. The latter grows at an altitude of 2700–3600 m.

COLORADO: Near La Plata P. O., 1898, *Baker, Earle & Tracy*,

472 (type in Herb. N. Y. Bot. Garden); Little Kate Basin, La Plata Mts., *568;* Cumberland Basin, *621.*

Cerastium Leibergii sp. nov.

Perennial with a slender, branched rootstock: stems simple, 4–5 dm. high, sparingly villous and viscid-puberulent; uppermost internode of the stem about 1 dm. long: leaves few and scarcely half as long as the internodes, linear-oblong, 2.5–3 cm. long, 6–7 mm. wide, the lower obtuse, the upper acutish, 1-nerved, thin, puberulent when young, ciliate on the margins: inflorescence viscid-puberulent; bracts lanceolate, 4–8 mm. long, not scarious-margined; pedicels in fruit 2.5–3 cm. long: sepals about 5 mm. long, lanceolate, viscid-pubescent, scarious-tipped and margined: petals scarcely twice as long as the sepals.

This is perhaps most nearly related to the preceding, but differs mainly in the broader, obtuse leaves and smaller flowers. It grows in open *Pinus ponderosa* forests at an altitude of 970 m.

IDAHO: Upper St. Mary's River, 1895, *J. B. Leiberg, 1103* (type in U. S. Nat. Herb.).

Cerastium graminifolium sp. nov.

Perennial with slender branched rootstock: stems 3–5 dm. high, densely short-villous and somewhat viscid, erect; uppermost node of the stem below the inflorescence elongated, 5–10 cm. long: leaves linear-lanceolate, 2–3 cm. long, 3–5 mm. wide, 1-nerved, short viscid-villous, mostly spreading: bracts lanceolate or ovate-lanceolate: pedicels in fruit 2–4 cm. long: sepals narrowly lanceolate, densely viscid-pubescent, only slightly scarious-margined, acute, 5–6 mm. long: petals 12–14 mm. long, cleft $\frac{1}{3}$–$\frac{1}{4}$ their length into oblong, obtusish lobes: capsule almost straight, about $\frac{2}{3}$ longer than the sepals.

This has gone under the name of *C. arvense*, but differs from the European plant, in the larger flowers, the more villous pubescence and the more acute leaves, which resemble much those of *Alsine graminea.* It grows in rich bottom lands.

WASHINGTON: Pullman, 1897, *Elmer, 177* (type in herb. N. Y. Bot. Garden).

IDAHO: near Lewiston, 1896, *A. A. & E. Gertrude Heller, 3013;* Upper Ferry, Clearwater Ferry, 1892, *Sandberg, MacDougal & Heller, 49.*

Draba sobolifera sp. nov.

A low cespitose perennial, but the leafy stolons often somewhat elongated: basal leaves oblanceolate, obtuse or spatulate, 1–2 cm. long and 3–4 mm. wide, sparingly stellate-villous, thick with indistinct midrib: peduncles 3–6 cm. long, stout, rather many-flowered: petals yellow, obovate, about 4 mm. long, more than twice as long as the rounded sepals: pedicels in fruit 7–8 mm. long: pod ovate, about 6 mm. long, 3–4 mm. wide, finely stellate: style about 5 mm. long.

This species is related to *D. ventrosa* and *D. alpina*. From the former it differs in the longer leaves and the finer and sparser pubescence; from the latter in the more elongated stems, the shorter and stellate pod and the shorter styles. It grows at an altitude of about 2500 m.

UTAH: Marysvale, above timber line, 1894, *Marcus E. Jones, 5936* (type), *5893e* and *5893az* (all in U. S. Nat. Herb.).

Draba argyrea sp. nov.

A cespitose tufted perennial, with underground horizontal stems; basal leaves obovate, 3–7 mm. long, in dense rosettes, densely and finely stellate, almost silvery; midvein indistinct: peduncles slender, 3–5 cm. long, naked, few-flowered: petals yellow, 3 mm. long, obovate, about twice as long as the ovate sepals: pedicels in fruit 5–8 mm. long: pods lanceolate, 6–7 mm. long, 2.5–3 mm. wide, minutely stellate: style about 1 mm. long.

This species resembles somewhat *D. oligosperma* in general habit and flowers, but the leaves are shorter and broader, more decidedly stellate and without the strong midrib, and the pod is longer. It also reminds one of *D. ventrosa* but is a more delicate plant with finer pubescence and longer pods. The type grew at an altitude of about 3000 m.

IDAHO: Rock crevices, Sawtooth Mountains, head of Pettit Lake, July, 1895, *L. F. Henderson, 3538* (type in U. S. Nat. Herb.).

Draba uncinalis sp. nov.

Small cespitose and pulvinate perennial: flowering stems scapiform, 2–3 cm. high, sparingly stellate, leafless; basal leaves in dense tufts, thick, rounded obovate, 3–4 mm. long, sparingly stellate, with indistinct midrib: inflorescence corymbiform, few-flowered; pedicels in fruit 4–5 mm. long: pod ovate, 3–4 mm. long and 3 mm. wide, glabrous or nearly so: style about 0.5 mm. long.

A small plant characterized by the short pod, found otherwise only in two North American species, viz., *D. andina* and *D. oligosperma*; but in both of those species the leaves have strong midribs and are less stellate. In habit it resembles most *D. nivalis*, but that species has a different pod. It grows at an altitude of 3500 m.

UTAH: Marysvale, Tate Mine, 1894, *M. E. Jones, 5940am* (type in U. S. Nat. Herb.).

Lesquerella Utahensis sp. nov.

A tufted perennial: stems ascending, 5–10 cm. (seldom 15 cm.) high; basal leaves 3–4 cm. long, petioled; blades oval or obovate, densely and finely stellate; stem-leaves smaller, oblanceolate or spatulate: petals yellow, about 8 mm. long, with cuneate blades, ½ longer than the oblong sepals: pedicels in fruit ascending, 5–10 mm. long: pod almost spherical or slightly transversely flattened, 3–4 mm. wide, finely stellate: style 4–5 mm. long, much longer than the pod.

This species is related to *L. Wardii*, *i. e.*, it has the same habit and pubescence and the pod is as in that species somewhat thicker than broad; but the latter is shorter, rounder, neither elongated nor acute at the apex. *L. Utahensis* grows at an altitude of 2000–3500 m.

UTAH: American Fork Cañon, 1880, *Marcus E. Jones, 1354* (type in herb. N. Y. Bot. Garden); Friser, 1880, *1810*; Marysvale, 1884, *5375e, 5958n*; Irelands Ranch, Salina Cañon, *5441*; Cañon above Tropic, *5312d*.

Stanleya runcinata sp. nov.

Stem stout, glabrous: basal leaves about 2 dm. long, lanceolate in outline, runcinately divided, softly pubescent with long white hairs; lobes broadly triangular or the lowest ones oblong: stem-leaves ovate to oblanceolate, more glabrous: raceme 1–3 dm. long, many-flowered: sepals linear, about 1 cm. long and 1 mm. wide, light yellow, glabrous: petals about ¼ longer; blades oblanceolate, about ⅔ as long as the glabrous claws: filaments glabrous, about twice as long as the sepals: pods almost erect and straight, 6–7 cm. long, 1.5 mm. wide, on spreading pedicels about 1 cm. long.

This species is perhaps most closely related to *S. pinnata*, but easily distinguished by the lobing of the basal leaves, the straight

pods, the oblanceolate blades of the petals and the glabrous filaments.

IDAHO (?): 1896, *Henderson* (type in U. S. Nat. Herb.).

Thelypodium ovalifolium sp. nov.

Perennial, perfectly glabrous: stems terete, 3–5 dm. high, ascending: earliest basal leaves about 5 cm. long, petioled with broadly oval blades, glabrous, entire, obtuse; the later ones oblanceolate; stem-leaves sagittate, 2 cm. long, thick, sessile and clasping, with short rounded basal lobes: inflorescence elongated: sepals oblong, 3 mm. long: petals about 5 mm. long with spatulate blades and slender claw: pedicels in fruit 4–5 mm. long, spreading: pods ascending, 1–2 cm. long and about 1 mm. wide, somewhat torulose.

This species is perhaps most nearly related to *T. paniculatum*, but differs in the short pods and the broad basal leaves.

UTAH: Panguitch Lake, 1894, M. E. Jones, *6015e* (type in U. S. Nat. Herb.).

Lepidium Georginum sp. nov.

Apparently biennial, cespitose from a slender taproot, 1–2 dm. high: stems hirsute with short spreading hairs: basal leaves 1–5 cm. long, deeply pinnately divided with ovate lobes; stem-leaves similar or the upper oblanceolate and entire; all more or less pubescent: inflorescence short: petals spatulate, slightly exceeding the sepals: pods pubescent, rounded oval, 4 mm. long, broadly winged above, forming at the apex two broadly ovate obtuse lobes, over 0.5 mm. long.

This species is in habit nearest *L. Wrightii* with which it has been confused; but it is less hairy and the pods are those of *L. dictyotum*.

UTAH: "Southern Utah," 1874, *C. C. Parry, 19* (type in herb. Columbia University); 1877, *E. Palmer, 40;* St. George, 1880, *M. E. Jones, 1614;* Milford, *1821* in part; 1894, *5110f.*

Thysanocarpus trichocarpus sp. nov.

Annual, perfectly glabrous, except the fruit, 1–3 dm. high: stem terete, branched: lower leaves oblanceolate or oblong, sinuately dentate, thick and somewhat glaucous; uppermost leaves linear or linear-lanceolate, entire: racemes often 1 dm. long: petals slightly over 1 mm. long; blades broadly spatulate: pedicels in fruit about 5 mm. long, recurved: pod nearly orbicular,

about 4 mm. wide, short-pubescent: wing-margins crenate or lobed, not fenestrate: style scarcely exceeding the wing-margin.

UTAH: Silver Reef, 1894, *M. E. Jones, 5163b*, in part (type in U. S. Nat. Herb.), *5149d* and *5139d*.

Trifolium lividum sp. nov.

Perennial, densely cespitose and tufted: branches of the caudex short and covered by the remnants of the leaf-bases and scarious stipules; free portion of the latter subulate-filiform: petioles 4–15 cm. long, slender, glabrous; leaflets linear-lanceolate or oblanceolate, very acute at both ends or cuspidate at the apex, 3–4 cm. long, glabrous above, sparingly appressed hairy beneath, green, entire-margined: peduncles 1–1.5 dm. high, sparingly appressed hairy: heads nearly 2 cm. in diameter; bracts linear-subulate to almost filiform, longer than the calyx-tube, glabrous, slightly if at all scarious-margined: calyx-tube 2.5–3 cm. long; teeth subulate-filiform, 4–5 mm. long: corolla about 12 mm. long, light purple with a darker keel.

This species is nearest to *T. dasyphyllum*, but is a larger, more glabrous and greener plant, and with much larger and narrower bracts. It grows at an altitude of about 3000 m.

COLORADO: Graymount, 1895, *P. A. Rydberg, 2442* (type in herb. N. Y. Bot. Garden); Alpine Tunnel, 1897, *C. L. Shear*.

Trifolium pedunculatum sp. nov.

Perennial, with a somewhat cespitose base: stems 2–4 dm. high, rather slender, striate, glabrous or with a few appressed hairs: stipules 2–3 cm. long, lanceolate, ½ or ⅔ of their length adnate to the petioles, denticulate: petioles 4–6 cm. long, slender; leaflets 3, oblanceolate to linear, acute, finely denticulate, 2–3.5 cm. long: peduncles 1 dm. or more long: heads 15–18 mm. in diameter, not bracteate: flowers subsessile, 10–12 mm. long, in fruit not reflexed: calyx-tube 2 mm. long, glabrous below, pubescent towards the throat; calyx-teeth subulate, the lower 3–3.5 mm. long: corolla purple.

This species is nearest to *T. longipes*, but differs in the smaller purple flowers and the calyx which is glabrous below.

IDAHO: Long Valley, 1895, *L. F. Henderson, 3096* (type in U. S. Nat. Herb.); near Sawtooth, 1896, *B. W. Evermann, 592*.

Lotus longebracteatus sp. nov.

Perennial, cespitose, decumbent: stems 2–3 dm. long, diffusely branched, grayish strigose: leaves thick, grayish strigose with a

distinct rachis; leaflets 4, linear to oblong or of the lowest leaves obovate, 1–1.5 cm. long or the lower shorter: peduncles 4–5 cm. long, 1–2-flowered; bracts linear, about equalling the calyx: calyx strigose, its tube and teeth each about 4 mm. long; the latter subulate: corolla about 14 mm. long, strongly curved upwards, the banner much exceeding the wings and keel: pod linear, straight, 2.5–3 cm. long, pubescent.

This is in some respects intermediate between *L. rigidus* and *L. Wrightii*, differing from the former in the narrower leaflets, in the shorter peduncles, longer bracts and narrower calyx-teeth and from the latter in decumbent habit, leaves with a distinct rachis and elongated peduncles.

UTAH: "South Utah," 1877, *Dr. E. Palmer, 94* (type in U. S. Nat. Herb.).

Lupinus depressus sp. nov.

Perennial, cespitose: stems decumbent, 1–2 dm. long, appressed silvery silky pubescent: petioles slender, 5–7 cm. long, also silvery silky; leaflets about 7, oblanceolate, usually obtusish, 1.5–2 cm. long, densely appressed silvery canescent; stipules subulate: racemes short, slightly exceeding the leaves; bracts lanceolate, short, deciduous: flowers 8–9 mm. long: calyx long-villous; lips ovate-lanceolate; the lower about ⅓ longer than the upper: corolla light bluish-purple; banner glabrous, slightly shorter than the wings.

Being perhaps most nearly related to *L. minimus*, it differs from that in the decumbent or spreading leafy stem and more silky pubescence. It grows in gravel on dry mountain slopes, at an altitude of about 1750 m.

IDAHO: Divide between St. Joe and Clearwater River, 1895, *John B. Leiberg, 1201* (type in U. S. Nat. Herb.); Lo-Lo Trail, 1880, *S. Watson, 80.*

Lupinus Evermannii sp. nov.

Perennial and densely cespitose: the numerous stems about 1.5 dm. high, slender, erect or ascending, leafy, appressed hairy: petioles 2–4 cm. long, also appressed hairy; leaflets oblanceolate to linear-oblanceolate, 1–2.5 cm. long, densely canescent on both sides with long appressed hairs; stipules lanceolate, acuminate: raceme very short-peduncled, dense and short; bracts lanceolate, short, deciduous: flowers 6–7 mm. long; pedicels and calyx densely pubescent with spreading hairs; lips of the latter ovate-

lanceolate, the lower about ⅓ longer than the upper: corolla purplish-blue; banner with a light spot, glabrous.

This species is nearest related to *L. holosericeus*, but the corolla is lighter and the pubescence of the calyx is spreading. It is also lower and more cespitose, resembling more *L. candicans* in habit, but has much smaller flowers.

IDAHO: Near Sawtooth, 1896, *B. W. Evermann, 533* (type in U. S. Nat. Herb.).

Lupinus Jonesii sp. nov.

Perennial, very stout: whole plant yellowish-green: stem over 1 mm. high, densely pubescent with two kinds of hairs, viz., a short pubescence and long spreading silky hairs; petioles about 5 cm. long, also pubescent with spreading hairs; leaflets 7–9, oblanceolate, densely appressed, yellowish hairy on both sides, 4–7 cm. long; stipules setaceous, deciduous: raceme long and dense, many-flowered; bracts subulate-filiform, much exceeding the buds; pedicels and calyx densely hairy with short spreading hairs: flowers about 16 mm. long: lips of calyx ovate-lanceolate; the lower about ⅓ longer than the upper: corolla white; the banner with a faint brownish spot; keel purple-tipped.

This species is nearest related to *L. leucophyllus*, but is less densely pubescent, the flowers are larger and in the type sheet whitish and the bracts are much longer. It grows at an altitude of about 4200 ft.

UTAH: Silver Reef, May 3, 1894, *Marcus E. Jones, 5143* (type in U. S. Nat. Herb.).

Lupinus adscendens sp. nov.

Perennial: stem 4–6 dm. high, appressed silky, leafy: petioles 5–10 cm. long, ascending, also appressed silky; leaflets about 7, linear-oblanceolate, 4–5 cm. long, acute, appressed silky on both sides but green; stipules subulate: racemes elongated, narrow; pedicels strongly ascending, rather long hairy: flowers about 12 mm. long: calyx grayish silky; the lower lip slightly longer than the upper: bract linear-subulate, much longer than the buds, almost equalling the calyx in length: corolla dark bluish-purple; the banner glabrous with a lighter spot.

This species is related to *L. laxiflorus*, but the calyx is not spurred and the bracts are much longer.

WYOMING: Headwaters of the Tongue River, 1898, *F. Tweedy, 129* (type in herb. N. Y. Bot. Garden); Head of Big Goose Creek, 1893, *F. Tweedy, 13*.

Lupinus argentinus sp. nov.

Perennial, densely appressed white-silky throughout: stem 4–6 dm. high: petioles 5–7 cm. long; stipules lanceolate-subulate; leaflets about 7, oblanceolate, densely silky on both sides, 3–5 cm. long, conduplicate and with strongly curved back: inflorescence rather short and dense; bracts ovate-lanceolate, short, deciduous: flowers about 1 cm. long: calyx and pedicels densely white-silky, spurred at the base; lower lip lanceolate, about one third longer than the upper: corolla bluish-purple; banner pubescent on the back, about as long as the wings: pods oblong, densely pubescent, about 3 cm. long and 5–6-seeded.

This species is nearest to *L. argophyllus*, but differs in the denser and whiter pubescence, the broader curved leaflets and the more pubescent banner. It grows at an altitude of 1200–2200 m.

UTAH: Near Reno, 1900, *S. G. Stokes* (type in herb. N. Y. Bot. Garden); Provo River, 1881, *M. E. Jones, 2169;* Salt Lake City, 1869, *S. Watson, 227.*

Lupinus comatus sp. nov.

Perennial, somewhat cespitose: stem about 3 dm. high, pubescent with long spreading silky hairs: petioles of the basal leaves about 1 dm. long, also pubescent with spreading hairs, leaflets narrowly oblanceolate, acute, 2.5–4 cm. long, green, pubescent on both sides; stem-leaves similar, but with shorter petioles; stipules linear lanceolate, long-acuminate: raceme short and dense, short-peduncled; bracts lanceolate-subulate, equalling or exceeding the buds; pedicels and calyx densely pubescent with spreading hairs; lips almost equal, ovate-lanceolate: flowers 8–10 mm. long: corolla bluish-purple, rarely white; banner slightly shorter than the broad wings.

The species is somewhat related to *L. laxiflorus* but the calyx is not spurred, the raceme short and dense, the flowers larger and the pubescence of the stem and petioles long and spreading.

COLORADO: Lake City, 1878, *F. N. Pease* (type in herb. Columbia University); Gunnison Co., 1895, *C. L. Pollard* (?) (U. S. Nat. Herb.).

Lupinus maculatus sp. nov.

Perennial, strict: stem 4–6 dm. high, finely appressed puberulent: petioles short, 2–4 cm. long, almost glabrous; leaflets 5–7, those of the lower leaves obovate-oblanceolate, mucronate; those of the upper oblanceolate and acute, sparingly appressed hairy beneath, glabrous above, 3–5 cm. long: inflorescence short-pedun-

cled and dense; bracts ovate-lanceolate, acuminate, deciduous; the short pedicels and the calyx densely pubescent with short spreading hairs; lips of the calyx ovate-lanceolate, the lower slightly longer than the upper: flowers 10–12 mm. long; banner light purple with a dark spot, glabrous, much shorter than the white or purple-tinged wings; keel white with purple tip: pods oblong, densely pubescent, 2.5–3 cm. long, 4–5-seeded.

The type was labeled *Lupinus parviflorus*, to which it is somewhat related, but the raceme is much denser, the flowers larger, the corolla of a different color and with a very dark spot.

UTAH: P. V. Junction, Wasatch Mts., 1883, *M. E. Jones* (type in herb. N. Y. Bot. Garden and duplicates in U. S. Nat. Herb.); Woods Class, 1882, *M. E. Jones*.

Lupinus pulcherrimus sp. nov.

Perennial, more or less cespitose: stems 3–6 dm. high, sparingly appressed hairy, leafy: petioles 3–6 cm. long, also appressed hairy or glabrate; leaflets 7–9, linear-oblanceolate, acute, appressed silky on both sides, but green; stipules lanceolate, subulate: raceme more or less elongated and rather dense, short-peduncled; bracts lanceolate, short-acuminate, shorter than the buds, deciduous: pedicels and calyx grayish silky; lips of the latter lanceolate, the upper somewhat shorter: flower about 1 cm. long: corolla dark purple; banner with a light spot, pubescent on the back: pods broadly oblong, 3–3.5 cm. long, 5–6-seeded.

This species is also related to *L. laxiflorus*, but the raceme is denser, the calyx scarcely spurred, and the flowers are larger. It also resembles *L. pseudoparviflorus*, but in that species the leaves are glabrous above and the calyx also spurred. From *L. adscendens* it differs in the spreading flowers and the short bracts.

WYOMING: Battle, Continental Divide, 1901, *F. Tweedy, 4215* (type in herb. N. Y. Bot. Garden); Headwaters of Tongue River, 1898, *Tweedy, 130;* Big Horn Mountains, 1899, *Tweedy, 2365;* La Barge, Uintah County, 1894, *E. Stevenson, 158.*

MONTANA: Divide between McDonald and Comas Lakes, 1901, *F. K. Vreeland, 996;* Little Belt Pass, 1896, *P. A. Rydberg, 3318; J. H. Flodman, 620;* Baltic, 1900, *E. V. Wilcox, 58.*

Lupinus laxus sp. nov.

Perennial and somewhat cespitose: stem 4–6 dm. high, slender, sparingly appressed, silky: petioles 3–12 cm. long, appressed

silky; leaflets 7–9, linear or linear-oblanceolate, 3–4 cm. long, green, but appressed silky on both sides; stipules subulate: racemes slender and lax; bracts lanceolate, short-acuminate, not longer than the buds: pedicels and calyx rather long, hairy: flowers about 8 mm. long: calyx not spurred; lips ovate, the upper slightly shorter: corolla light bluish-purple; banner broad, somewhat shorter than the wings.

This species is closely related to *L. laxiflorus*, but the flowers are smaller and lighter and the calyx is not spurred. It grows at an altitude of about 2000 m.

MONTANA: Forks of the Madison, 1897, *Rydberg & Bessey, 4442* (type in herb. N. Y. Bot. Garden), also *4443a*.

WYOMING: La Barge, Uintah Co., 1894, *E. Stevenson, 157* (somewhat more hairy than the type).

Lupinus leucanthus sp. nov.

Perennial, about 6 dm. high: stem minutely strigose, leafy: petioles about 6 cm. long, almost glabrous; leaflets 5–7, narrowly oblanceolate, 4–5 cm. long, acute or short-acuminate, glabrous above, sparingly appressed hairy beneath; stipules subulate: raceme lax; bracts lanceolate, acuminate, about equalling the pedicels, 6–8 mm. long: pedicels and calyx appressed short-hairy; lower lip of the latter linear-lanceolate, about ⅓ longer than the ovate upper one: corolla white with a brownish spot on the banner; the latter glabrous and almost equalling the wings.

This species is nearest related to *L. Scheuberae*, but differs in the larger white flowers and the longer upper lip of the calyx. The type sheet bears the name *Lupinus barbiger* Wats., but the plant is not at all related to that species.

UTAH: Springdale, 1894, *Marcus E. Jones, 5249e* (type in U. S. Nat. Herb.).

Pachylophus macroglottis sp. nov.

Acaulescent or nearly so: leaves 8–15 cm. long, tapering into a margined petiole; blades broadly oblanceolate, acute, sinuate-dentate, sparingly puberulent, and villous ciliate on the margins and the veins, very thin: hypanthium very long and slender, 12–14 cm. long, sparingly villous or nearly glabrous, gradually widening into a funnelform throat, which at the insertion of the sepals, petals and stamens, is about 1 cm. in diameter: sepals lanceolate, gradually long-acuminate, about 5 cm. long and much exceeding the broadly obcordate petals, which are about 3.5 cm.

long and fully as wide, very thin, at first white but turning pink in age: filaments about 2.5 cm. long: anthers versatile, 1.5 cm. long and 2 mm. wide: style exserted; lobes of the stigma about 5 mm. long: capsule with rather strong sinuately lobed ridges.

This species differs from *P. caespitosum* (Nutt.) Raimann in the villous ciliate leaves, the longer hypanthium which is much broader at the throat than in any of the other species, the longer sepals which much exceed the petals in length, and the less tubercled ridges of the pod. It grows in cañons at an altitude of 1500–2800 m.

COLORADO: Tributaries of Turkey Creek, 1900, *Rydberg & Vreeland, 5857* (type).

Pachylophus exiguus (A. Gray) Rydb. nom. nov.

Oenothera exigua A. Gray, Pl. Fendl. 1849.

This species was merged into *P. caespitosus* by Dr. Watson; but it is perfectly distinct. The plant is nearly always caulescent with a stem 0.5–2 dm. high, the leaves and hypanthium are villous as in the preceding species, but still more so, the hypanthium is fully as long, but less widened at the throat, and the angles of the pod with more prominent sinuately lobed crests than in *P. caespitosus*. This species is represented in the New York herbaria by the following specimens:

COLORADO: Rocky Ford, 1891, *C. S. Crandall;* Mesas near Pueblo, 1900, *Rydberg & Vreeland, 5858;* Rocky Ford, 1900, *G. Osterhout*, 2085.

NEW MEXICO: White Mountains, 1897, *E. O. Wooton, 659.*

ARIZONA: Walnut Cañon, 1898, *MacDougal, 341.*

Androsace puberulenta sp. nov.

A puberulent rosulate annual: leaves oblanceolate, 1–3 cm. long, acute, entire or sinuately denticulate, densely puberulent: peduncles several, 3–10 cm. long: bracts narrowly lanceolate, 3–4 mm. long: pedicels 1–5 cm. long, spreading, densely puberulent: calyx 3–4 mm. long, cleft to the middle; tube glabrous, turbinate; lobes lanceolate, strongly keeled, densely puberulent, in fruit much exceeding the short capsule: corolla white, about equalling the calyx.

This species is in habit intermediate between *A. subumbellata* and *A. diffusa*, but differs from both in the densely puberulent

pedicels and calyx-lobes. In both specimens mentioned the calyx-lobes are of the length and shape of the valves of the maturing capsules, while in *A. puberulenta* they are much longer. The range of the species extends from Manitoba and the Mackenzie River south to New Mexico. The type was collected in southern Colorado near Veta Pass, 1900, *Rydberg & Vreeland, 5772* (N. Y. Bot. Garden).

Gilia subacaulis sp. nov.

Apparently biennial with a slender taproot: stem less than 1 dm. high, almost leafless, diffusely branched, glandular-puberulent: leaves almost all basal, 1.5–3 cm. long, pinnatifid with triangular to oblong divisions, glandular-puberulent, or slightly white-villous when young: inflorescence open; pedicels 2–4 mm. long: calyx 2–2.5 mm. long, puberulent, scarious between the green ribs; lobes lanceolate, about half as long as the tube, acute: corolla 4–6 mm. long, funnelform, fully twice as long as the calyx, its tube distinctly exserted: stamens included: capsule rounded ovoid, acute, 4–5 mm. long.

This is related to *S. inconspicua*, but differs in the almost leafless stem, and the smaller corollas which have a comparatively longer tube. The following specimens belong here.

WYOMING: Point of Rocks, 1901, *Merrill & Wilcox, 607* (type in Herb. N. Y. Bot. Garden).

UTAH: St. George, 1877, *Palmer, 328*; 1874, *Parry, 199*.

COLORADO: Gunnison River, 1894.

Mertensia subpubescens sp. nov.

Mertensia Sibirica Rydb. Mem. N. Y. Bot. Gard. 1: 335. 1901; mainly.

Perennial with a thick rootstock: stem simple, stout, 6–10 dm. high, glabrous throughout: lower leaves petioled, the upper sessile; blades broadly lanceolate, 5–10 cm. long, tapering at both ends, thin, glabrous or nearly so above, short-pubescent beneath and ciliate on the margin: inflorescence a rather many-flowered short panicle; pedicels slightly strigose: calyx-lobes oblong-linear, obtuse, ciliate on the margin, 2–2.5 mm. long, about ¼–⅓ as long as the corolla-tube: corolla about 12 mm. long; the tube only slightly longer than the limb: filaments broad and dilated, broader than the anthers and about half as long.

This is perhaps nearest related to *M. ciliata*, but is easiest distinguished by the pubescent lower surface of the leaves. It

grows along streams at an altitude of 2000–2200 m. The following specimens from Montana belong here:

MONTANA: Spanish Basin, 1897, *Rydberg & Bessey, 4876* (type in herb. N. Y. Bot. Garden); near Indian Creek, *4872;* Bridger Mountains, *4875;* Mystic Lake, 1895, *C. L. Shear, 3076;* Deer Lodge County, 1901, *Mrs. Emma W. Scheuber, 42;* Basin, 1902, *Kelsey.*

Heliotropium spathulatum sp. nov.

Heliotropium curassavicum Hook. Fl. Bor. Am. **2**: 81. 1840. Not L.

? Heliotropium curassavicum obovatum DC. Prod. **9**: 538. 1845. Not *H. obovatum* D. Don.

A glabrous, more or less glaucous, fleshy perennial with ascending more or less branched stems, 3–5 dm. high: leaves spatulate, fleshy, indistinctly nerved, 2–5 cm. long, obtuse or rounded at the apex, tapering at the base and the lowermost petioled: inflorescence branched into 2–5 racemes; these often starting from one point at the end of the common peduncle: calyx about 3 mm. long, cleft to the middle; its lobes ovate-lanceolate, acute: corolla white or slightly tinged with blue, 6–8 mm. long; the limb of about the same width: nutlets 2.5–3 mm. long, scarcely rugose.

This is the common plant of the Rocky Mountain region that has been known as *H. curassavicum* L., but has much broader leaves, more than twice as large flowers and larger fruit than the cosmopolitan plant found on our eastern seaboard and in the southern states. It is probably the same as the plant collected by Douglas in the Blue Mountains of Oregon and briefly described in the places cited above. Hooker states that in the Blue Mountains were the only places where Douglas found *H. curassavicum.* In the Columbia herbarium there is a specimen, labelled: "California, *Douglas.*" If this specimen is one of those collected in the Blue Mountains and described by Hooker and DeCandolle, the synonyms cited above should be excluded; for the specimens evidently belong to the short-leaved and smaller-flowered form of *H. curassavicum* common on the Pacific coast and described by Willdenow under the name *H. chenopodioides.*

H. spathulatum is fairly common in meadows throughout the Rocky Mountain region and the great plains from Assiniboia and Washington to Iowa, New Mexico, Chihuahua and California. The type was collected at Great Falls, Montana, 1890, *R. S. Williams, 542* (in herb. N. Y. Bot. Garden).

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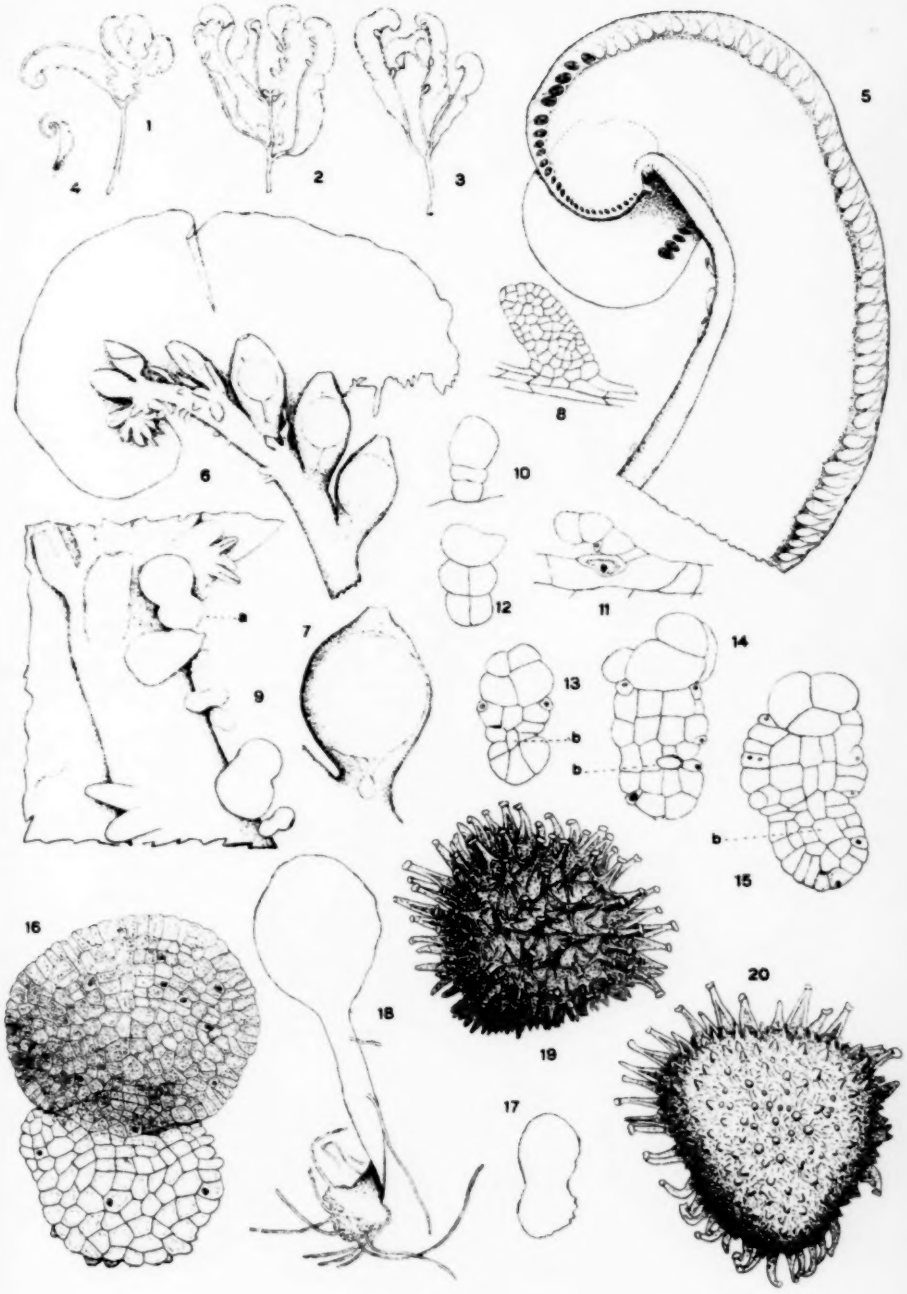

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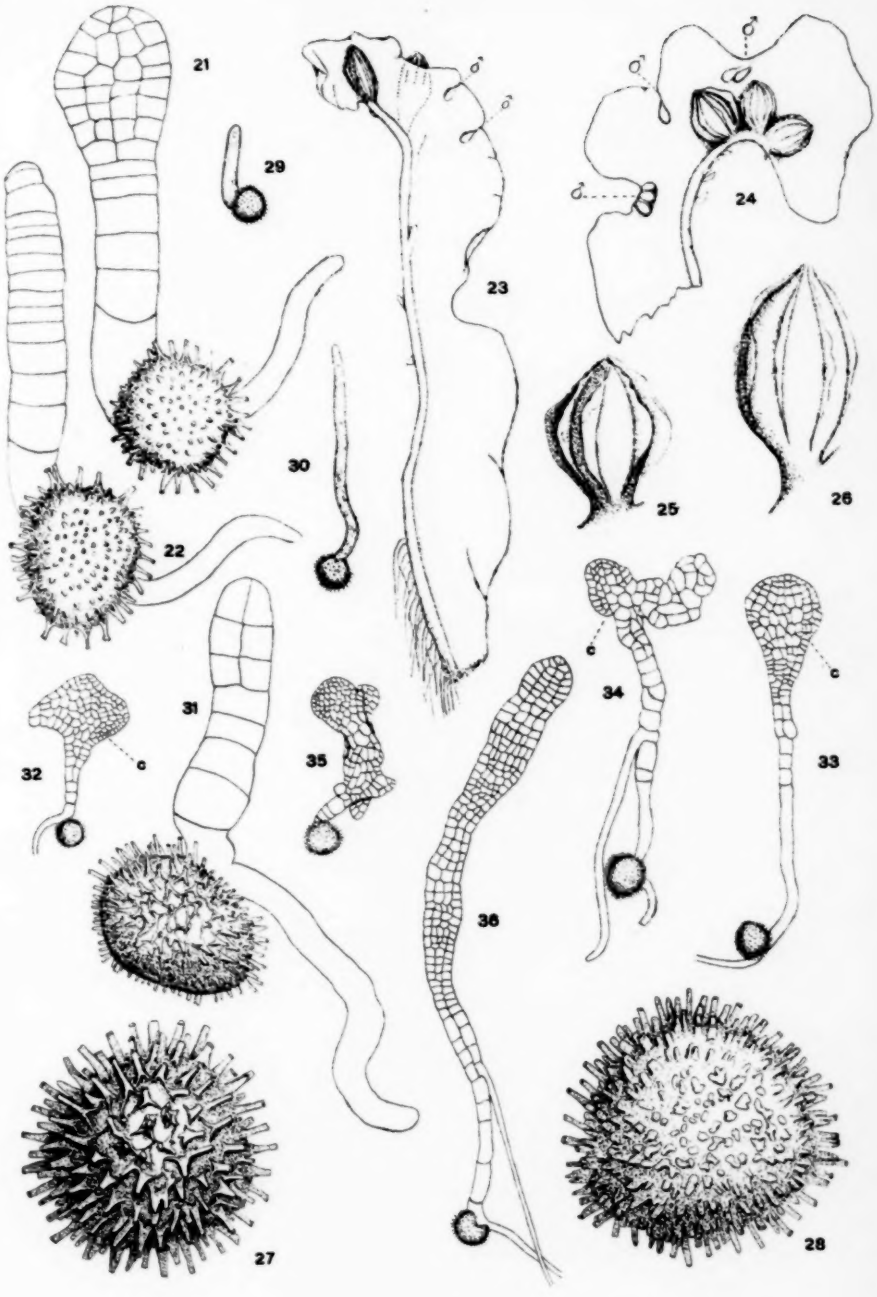

21 and 22. RIELLA AMERICANA Howe & Underw.

23-36. RIELLA AFFINIS Howe & Underw.

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